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ANNUAL REPORT

1949

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

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SILT IN THE COLORADO

> "The upper two-thirds of the basin rises from four to eight thousand feet above the level of the sea. This high region, on the east, north, and west, is set with ranges of snow-clad mountains, attaining an altitude above the sea varying from eight to fourteen thousand feet. All winter long, on its mountain-crested rim, snow falls, filling the gorges, half burying the forests, and covering the crags and peaks with a mantle woven by the winds from the waves of the sea--a mantle of snow. When the summer-sun comes, this snow melts, and tumbles down the mountain-sides in millions of cascades. Ten million cascade brooks unite to form ten thousand torrent creeks; ten thousand torrent creeks unite to form a hundred rivers beset with cataracts; a hundred roaring rivers unite to form the Colorado, which rolls, a mad, turbid stream, into the Gulf of California."--J. W. Powell, 1874.

To the tourist, the Colorado River basin is an area of scenic grandeur and majestic panoramas, and these are of infinite variety. They include high alpine scenery "on its mountain-crested rim," dark conifer forests, sunny mountain meadows filled with flowers, foothills of various contour, fertile, irrigated valleys, and endless expanses of desert and semidesert lands carved by timeless geologic forces into fantastic forms. Thus, in its opportunities for recreation and inspiration, the Colorado River basin is a virtually limitless resource.

To the stockman, the Colorado River basin is a vast range resource. His herds and flocks graze from desert lowlands in winter, through intermediate foothills and plains in spring, and up to mountain slopes and alpine pastures during summer, returning in fall to the foothills and plains, and then, completing the cycle, back to the desert for winter. To the stockman all these lands are interrelated through linked seasonal use. He is concerned, or he should be concerned, with improving and maintaining the forage resource upon which his livelihood depends.

Much of this same area is grazed by herds of game--deer, elk, and antelope. The sportsman is concerned, or should be concerned, with maintaining these game herds, and, in consequence, with maintaining the forage resources they utilize. He is concerned likewise with maintaining the quantity and quality of water, and the plant life in streams and lakes that make a habitat for fish. Both the sportsman and the stockman have a common interest in the maintenance and improvement of range where there is insufficient forage for both livestock and game, and where a balance must be reached.

To the lumberman, the mountain forests that rim the Colorado Basin are important as a source of raw materials for his mill. He is concerned, or he should be concerned, with the protection of these forests from fire and disease, and with their harvesting in such a way that their productivity is kept at a maximum level.

To the irrigationist and to other water users--whether their use be for a steam boiler, an electric light, or drinking water--the Colorado River also has a special meaning. To them water in the Colorado and its tributaries is like blood in an artery, the very life of the region in which it lies. To them the condition of the land in the Colorado Basin, traversed by tourists, fishermen, and hunters, logged by woodsmen, and grazed by livestock and game, is of well-nigh vital significance. Their claim on the Colorado transcends in monetary value that of all others.

Water for irrigation, power, and industrial and domestic use is eagerly sought by six States--Wyoming, Colorado, Utah, Nevada, Arizona, and California. All the water in the Colorado would not suffice to fill the plans made for it by these several States. Proposed reclamation projects on the river, involving dams and diversions, run into a total cost of billions. In each of these projects the engineer must face the problem of siltation, which is illustrated, simply and starkly, by the current rate of siltation in Lake Mead. Present estimates are that 135,000 acre-feet of sediment are brought into Lake Mead annually, and it is estimated--not hysterically, but by cool engineering calculation--that the effective life of this great reservoir is a mere 200 years. Is this all the longer civilization in our Southwest will last--three lifetimes, end to end?

In order to catch silt and increase the life of Lake Mead, it is now proposed to build a series of dams in the Colorado and its tributaries at a cost several times greater than the value of Hoover Dam itself. And then, to protect these secondary dams, may not a third set, several times more costly still, be necessary? The costs are staggering, but they indicate the value of the Colorado to those who need its water.

The origin of most of the water in the Colorado, as indicated in the quotation from Powell, is in melting winter snow in the mountains. A relatively small part of the water is contributed by summer storms. Much of the basin is formed of relatively soft rocks, sandstones and shales, and unfortunately includes a large area of extremely low precipitation and naturally sparse vegetation. The result is that a large proportion of the sediment in the Colorado is carried into the river by only a small proportion of the total runoff. Summer storms of high intensity bring sediment from the land surface down into tributary channels as well as into the main stem of the river. If a particular summer flood spends itself, and deposits its load of sediment before reaching the river, sooner or later another flood, or recurrent high waters from snowmelt, will scour the materials out of the channel, and the river will sort them over and carry them toward Lake Mead.

It is important to recognize that much silt in the Colorado is the result of natural, geologic erosion. This cannot be blamed upon overgrazing or other land abuse, and probably Man can do nothing on the land that will prevent it. Silt-detention dams are the only remedy so far as we now know, a palliative rather than a cure. But there is no reasonable doubt that normal sediment loads, great as they may be in some parts of the Colorado Basin, have been enormously stepped up because of land abuse. The evidence is to be seen on every hand.

Early geological explorers in the Southwest have noted that the dominant phase of the geological cycle in the lowlands of this general region was one of aggradation rather than degradation. Conditions that existed in 1878-1880 are described by Dutton as follows:

> "Most of those lateral canyons. . .are slowly filling up with alluvium at the present time, but very plainly they were much deeper at no remote epoch in the past. The lower talus in some of them is completely buried, and the alluvium mounts up on the breasts of perpendicular scarps. In some cases a smooth floor of alluvium extends from side to side of what was originally a canyon valley. The recurrence of a climate sufficiently moist to sustain a vigorous perennial stream would probably sweep out all this unconsolidated alluvium and return the valley to its former condition of an ordinary canyon."

Nowadays the picture is different. Nearly every one of these alluvium-filled valleys has been incised by a deep axial gully from which tributary gullies are eating back into side drainages. When floodwaters pour off the slopes the valley no longer traps sediment or holds the water in check; instead the torrent rushes down a prepared pathway, and if not already loaded to capacity, it cuts out and picks up more of the valley fill, thus making the way even less difficult for succeeding floods.

The Colorado River basin embraces an area of some 243,000 square miles. In an area so vast as this, one would expect enormous variations in geology, topography, soils, climate, and vegetation--and they are there. From mountain peaks to desert bajadas, from chasms and gorges to gently sloping, flat-floored alluvium-filled valleys, all types of topography may be encountered. Precipitation varies from 40 inches or more in the cool mountains to virtually nothing in some of the hot desert lowlands. Vegetation varies from alpine meadows and dense mountain forests to the scattered shrubs of deserts, and there are large areas of badland and bare rock virtually without a vegetal cover. Such diversity in the nature of the country creates diversity in the character of technical problems, and calls for diverse skills in scientific research and in land management.

Although it is clear that land abuse is the cause of a new epicycle of erosion, it is not clear how much of the erosion in the bewildering variety of sites and plant communities in the Colorado Basin is due to land abuse rather than natural causes. And although we know that the basic land-management problem over most of the grazed area is one of restoring a vegetal cover within the natural limitations and potentialities of each site, we know how to do this on only a fraction of the total. Many facts and principles necessary to sound land management have been developed, some within the Colorado drainage basin, many more adjacent thereto, but the specific questions remain; Where will these facts and principles apply? Where will modification be needed? Where must new knowledge be gained?

A large proportion of the silt originates from lands that are used only for grazing. The most important vegetal types in sediment production appear to be pinyon-juniper, northern desert shrub, and grassland. These together make up well over two-thirds of the land area of the Colorado River basin. How much each type contributes and where is not yet known, for detailed vegetal type maps--and for that matter, accurate maps of the terrain--and long-term records of stream flow and sediment in the tributaries of the Colorado, still are lacking. As an indication of how little we know about the process, the relative contribution of sediment from sheet erosion, gully erosion, and channel erosion, is still a subject of debate with estimates as to the various sources ranging from 10 to 90 percent of the total.

Much emphasis is put upon sediment production of the desert lowlands of the Colorado Basin, and rightly so. However, the contribution from the mountains should not be ignored. Even though its part of the total may be considered slight, we know that widespread accelerated erosion is taking place. Silt is being moved downstream by stages. Flood materials, carried out of mountain canyons, are dumped where the gradient lessens, only to be carried forward toward the Colorado by subsequent high stream flow in spring, or by late summer floods. Moreover, the potential contribution of sediment from the mountains is enormous. Deep soil mantles, many on steep slopes, provide an immense store of fine materials, and if the protective vegetation is weakened or lost, these fine materials, aided by gravity, can be quickly carried down into lower channels. Were vegetation on the mountains ever to be so lost generally, these fine materials would be only the beginning, for flood waters would gain such cutting and carrying power in rushing down the barren slopes as to make the sediment loads of present-day floods seem trivial by comparison. There is no imminent prospect of so great and general a catastrophe: under reasonably good management the present vegetal cover should be maintained indefinitely, and it is to be hoped that it may soon be improved where it is now deficient. Nevertheless the poised potential for sedimentation from these mountain lands should not be minimized nor forgotten.

The construction of certain silt-detention dams above Lake Mead to prolong its usefulness is justified by economic values. So is the cost of channel improvements that will keep silt out of the streams. So, too, is the cost of gully plugging and contour trenching on many upland slopes. The most elaborate engineering projects, however, even carried to the utmost limits of the watershed, are not the complete solution. They deal with only one segment of the economy of nature and leave an important part of the job undone. A law of this economy is that *the cheapest place to store sediment is on the watershed, beneath the crowns of plants and their litter.* These corollaries follow: the more effective vegetation is in keeping sediment in place, the fewer and less costly the downstream engineering works needed; and, the greater the investment in engineering works, the greater the need for stabilizing watershed cover so as to promote infiltration and hold the soil in place. Thus, the skills of land managers must be combined with the skills of engineers in lessening silt in the Colorado. The need requires that land managers devote their best efforts to increasing vegetal cover up to the productive potential of each site.

Most of the silt in the Colorado River that land managers can do anything about comes from lands that are used for grazing. Heavily forested lands make up only a small proportion of the total, and contribute much silt only after fire or destructive logging. Cultivated lands are not extensive. Proper grazing is therefore of first importance in a land-management program. The intrinsic value of many of these grazing lands is low, so low that private individuals cannot afford to own them. The greatest part of the area that is utilized for grazing must, therefore, be managed extensively rather than intensively. Management practices must be applied at low cost.

The specific management that needs to be applied in particular areas is, of course, something that still needs to be worked out by research and by empirical trials. However, control of grazing animals, including numbers, seasons of use, and kind of animal, is certainly essential. Management practices, criteria of proper use, and indicators of range condition and trend that have been found useful in other parts of the West can be utilized as guides while management experience and research in the Colorado basin itself are developing more adequate tools.

In a relatively small part of the Colorado River basin intensive methods may be applied. These include artificial reseeding on especially productive lands where returns from increased forage are sufficiently high to justify the cost. Such projects may be justified in part by the relief they afford to grazing pressure on less favorable sites nearby. Furthermore, intensive methods have a place on rapidly eroding sites known to be capable of restoration, chiefly in the foothills and mountains. More needs to be known about the possibilities of artificial revegetation on difficult sites, particularly in arid lowlands.

What should this management be, and how is it to be applied? How is this reseeding to be done? Where should the first efforts be made? For although we have a great deal of information on range management, watershed management, and reseeding in areas adjacent to the Colorado River basin, and indeed a beginning in the basin itself, the fact is that this vast area is largely unknown. The area is so enormous and varied, and the problems are so numerous, that using all the resources of research that we can spare the task appears staggering. It is necessary, therefore, that the efforts of all agencies and of all forest and range experiment stations complement rather than duplicate each other.

One of the first needs is a better appraisal of problems in the Colorado River basin. It is necessary, as a preliminary to more intensive research and as a basis for management, that extensive observational studies be made. Ways and means of classifying the various parts of the basin according to vegetal type, according to productive potential, according to condition and trend, and according to the amount of silt contributed, need to be worked out.

During 1950, therefore, exploratory studies will be undertaken. Representatives of all research divisions except Forest Management will visit parts of the Colorado River basin that are believed to be especially important from the standpoint of siltation. Their effort will be to become familiar with the country, to appraise specific research problems, and to plan possible future research. In the divisions of Influences and of Flood Control Surveys, infiltrometer work will be carried out on various types so as to determine infiltration rates and sediment contribution under various conditions. This information will be utilized in an effort to evaluate sources of silt contribution more adequately. The effort in range management will be to ascertain where protected areas provide an ecological basis for judgment of range condition and trend, and what indicators may be useful. The effort in artificial reseeding will be to see how far the application of known practices can be carried out and, on important sites where known practices do not apply, to begin trials of possible species and methods.

RANGE MANAGEMENT RESEARCH

PROBLEMS OF THE INTERMOUNTAIN REGION

Over-all problem

The most universal land use in the Intermountain region, during most of the 100 years since settlement, has been grazing. Practically the entire area has been overgrazed in one way or another, and as a result there is one over-all problem in range management--that of rehabilitating depleted vegetation and of improving deteriorated sites. Much improvement has taken place under the regulations that have been imposed on grazing in the last 50 years, but even where improvement has occurred it is usually far from complete. The need for rehabilitation applies to vast areas--desert lands, sagebrush plains and foothills, mountain brush types, forest types of various kinds, and mountain grasslands. On practically the entire grazable area of the region, irrespective of type, vegetation has been changed for the worse as a result of abuse, and soil has been disturbed in greater or less degree.

Although nearly all vegetation has changed in the same direction, the specific character of change varies with vegetal type. In each type the net change includes reduction or elimination of desirable forage plants and increase of less desirable plants. Where the desirable forage plants are woody, like black sage, bud sage, and winterfat in the salt-desert shrub association, or bitterbrush or cliffrose in the sagebrush association, remnants of the original forage plants generally persist. Usually these have been weakened and mutilated by grazing animals. In other cases the plants are tall enough so that their crowns escape grazing. As a rule these plants are old, with little current reproduction in evidence. In both cases a residual stand of desirable species provides a seed source, and the management problem may be chiefly one of lessening grazing pressure so that young plants can become established.

On the other hand, where the desirable forage plants are herbaceous, the problem is likely to be more difficult. If grazing has been very severe, these desirable species may have been largely eliminated, and the seed source, if any, is likely to be small and poorly distributed. The first improvement must come, therefore, not from the most desirable species, but from those of lesser value that are still present in the stand. This appears to be the situation in many foothill and mountain types. Whatever the seed source of desirable plants, an increase or an invasion of undesirable plants, such as sagebrush, cheatgrass, or tarweed, generally retards the increase of desirable plants. Some of these undesirable plants are poisonous to livestock, but not all.

Adverse changes in vegetal composition as a result of overgrazing are serious, for in the aggregate the loss in grazing value in so great a resource is tremendous. But even more serious are the effects of thinning the cover so that accelerated erosion has gotten under way, or the introduction of a new kind of cover which is less effective than the original cover in preventing erosion. Cheatgrass, because of its inflammability, is a case in point. Erosional problems as a result of overgrazing vary greatly from site to site, but they are widespread in the Intermountain region.

Possible solutions to problem of deterioration

To anyone unfamiliar with the West the solution is easy: simply eliminate all grazing for awhile and let the ranges recover. This solution, if it were possible of application, would of course ruin the range livestock industry. Moreover, some ranges would take an impracticably long time recovering--probably several human lifetimes, and on some rest alone would not bring about recovery.

Actually all range lands cannot be retired from grazing because they are under varied ownerships; and those under public ownership cannot be retired from grazing unless the retirement is justified by a more valuable alternative use. Thus the range management problem is one of restoration under use. Generally speaking, management of some kind is the only answer to the problem of widespread range deterioration. The ranges of the Intermountain region are too vast in extent, and the land values are too low, to justify the costs of intensive rehabilitation. The only range lands that can be treated intensively by reseeding, contour terracing, etc. at present, are areas of costly flood or fire hazard, or areas that are naturally capable of producing a heavy crop of forage, thus giving a profitable return on the investment.

When the problem of widespread range deterioration is examined more closely--when one gets down to specific types and sites, specific degrees of deterioration, specific kinds of animal use, and the like--it quickly becomes evident that more knowledge is needed to do the management job. This is where research comes in. It is true that materially better management could be had on practically all Intermountain range lands if facts and principles already known were more generally applied. Lack of research knowledge is hardly a valid reason for continuing to overgraze depleted range where it is obvious that vegetal cover is insufficient to protect the soil or where it is obvious that desirable forage species are losing ground. But there are many ranges where condition is not so obvious and where trend is not so easily seen. Here are many questions that need to be answered before anything more than tentative steps in management can be taken. And even where the first step can now be taken with assurance, what about the next step in management? What is the ultimate goal? The function of range management research is to answer these questions for specific types and sites.

Special problem areas

Recognizing that the problem of range deterioration is widespread, it is still possible to specify three general problem areas where need for research appears most urgent.

Mountain grasslands

The first are mountain grasslands, ranging from herbaceous vegetation in the alpine and subalpine zones down to herbaceous openings in forest or shrub communities at lower elevations. These herbaceous types are not localized, but occur in the mountains throughout the region. They are of particular concern to Administration in its efforts to improve national forest ranges for more effective watershed protection. Because certain slopes have been denuded of their herbaceous cover by overgrazing, mud-rock flows have occurred in some places. However, even where considerable soil stability has been achieved as a result of increasing vegetation, and where mud-rock flows occur only rarely at present (as above Mt. Pleasant, or at the head of Manti Canyon in central Utah), accelerated erosion continues apace and sites continue to deteriorate. Techniques for rehabilitating many of these slopes are still to be developed. Probably many of them will require extensive artificial seeding. Even using the best means now known, there is reason to think that some of these soils are no longer deep enough to support sufficient vegetation to protect themselves against erosion. This problem of the stabilization of mountain soils is clearly one of the utmost urgency.

Granitic soils of southwestern Idaho

The second problem area is on granitic soils in that part of the Northern Rocky Mountain physiographic province in southwestern Idaho. The problems of accelerated erosion are intensified here by a soil that is naturally droughty and loose, and abnormally so now because of the loss of fine materials through accelerated erosion. The causes for this condition are a combination of overgrazing, invasion of cheatgrass, and repeated fire. The results are not only a continuing deterioration of soils on the slopes, but continuing siltation of downstream irrigation works. The costs of this siltation, as well as continuing watershed deterioration, make it imperative that rehabilitation be undertaken. However, less is known about rehabilitation, either natural or artificial, of vegetation on this granitic soil than perhaps of any other in the region.

Colorado River basin

The third problem area is the drainage of the Colorado River, including most of the Colorado Plateaus, part of the Wyoming Basin, and part of the Middle Rocky Mountain province. This is a problem area because of the silt it contributes, particularly from desert and semidesert lands, to the Colorado. The importance of the Colorado

River in developing irrigation and power in Wyoming, Utah, Colorado, Nevada, Arizona, and California is very great. There is considerable information available in corresponding types in other parts of the Intermountain region, and perhaps also from adjacent regions, which would apply to the siltation problem of the Colorado River. However, extensive studies in the basin of the Colorado itself are lacking, and until on-the-ground study is made, specific technical problems cannot be understood, and known principles cannot be applied.

Special problems

Certain kinds of problems extend across problem area boundaries, and indeed over most of the range lands of the region. For convenience these will be considered under four rather broad headings, the ecological basis for management, criteria for judging range condition and trend, influence of animals in the range complex, and control of undesirable plants, and the most important specific phases of these problems will be described.

Ecological basis for management

Fundamental research upon which ecological studies directly applicable to range management are based, provides this "ecological basis." Such research includes studies of the distribution of plant populations both in space and in time, community structure, phenological and growth characteristics of individual species, environmental requirements for successful establishment, and interrelations between plant behavior and habitat factors.

The fundamental research most urgently needed, however, is that which will increase our knowledge of the vegetation and soil of normal range. Whatever the range owner or administrator does by way of technical management on a given site, he is guided, for better or worse, by his conception of what is normal for that site. He is often guided for worse rather than for better, at present, because his conceptions of normal productive potential and normal erosion characteristics are often wrong. They are wrong for the reason that his experience has been, not with virgin range, but with range that is greatly changed, now depleted and deteriorated by 75 to 100 years of grazing. Where studies have been made to reconstruct the original native vegetation, as at the Desert Experimental Range and in the subalpine zone of the Wasatch Plateau, the results have shown that the productivity potential of the range and its normal soil stability are much greater than those who dealt only with the open range were able to imagine. There is every indication--from exclosures and artificial reseeding trials for example--that for ranges between these environmental extremes the same thing is true.

Part of the effort in fundamental research to improve our concepts of the normal lies in working out normal processes of change. These include normal plant succession and soil development. One important application of such knowledge is that it serves as a standard for evaluating present-day trends caused by grazing, rodents, climate, and other factors in the range complex.

The reason why an understanding of the normal--vegetation, erosion, and developmental processes--is so urgent is that a factual basis is needed by land managers for judging present range condition and for inferring the character and velocity of range trend. The greater the factual basis for these judgments, the more rapidly range management will improve: fundamental ecological research is the key to fully effective management.

Criteria for judging range condition and trend

Condition and trend studies are possible in some areas on the basis of what we already know about the ecology of the vegetation. In other areas intensive ecological research is necessary before reasonably reliable indicators of condition and trend can be established. Nevertheless, because of the widespread character of the problem and the necessity to take effective action before much more deterioration occurs, condition and trend studies should be made as quickly as possible and at practicable levels of intensity for every major type. Their value, of course, will vary according to the soundness of their basis in an understanding of normal vegetation and soil, as outlined in the preceding section. It is therefore highly desirable that effort on such "quickie" studies should be balanced by ecological research to deepen and improve this understanding of the normal, and that the first criteria of condition and trend be revised as new knowledge is gained.

At the same time that information is gathered on condition and trend, either by fundamental ecological studies or by "quickie" methods, facts on rate of change in various condition classes, under various treatments, need to be collected. The amount of change to be expected in a given time under certain grazing pressures should be known, and those areas where lessening grazing pressure will be effective in rehabilitation should be distinguished from those requiring cultural measures, such as clearing, burning, planting, and the like. For example, on some ranges that look badly beaten as a result of current grazing, the conclusion can be reached that artificial reseeding is the needed remedy, when in fact, protection from grazing (which would be needed with reseeding anyhow) reveals the presence of a native seed source sufficient for natural recovery.

Influence of animals in the range complex

The effects of grazing at different intensities, different seasons, and by different classes of animals are of course one of the principal questions that range-management research needs to explore. Most of the effort of the division is directed toward this question, with sheep at Dubois, Idaho, and the Desert Experimental Range, sheep and cattle on summer range on the Wasatch Plateau, and deer alone, and deer in combination with sheep and cattle, generally in Utah. The purpose of these studies, particularly the pasture studies, is to develop and test systems of grazing and other management techniques for improvement of the range. They also lend themselves to development of criteria of condition, trend, and proper utilization.

The effects of grazing on other animals, and the influence of other animals on the range, need more attention than we have been able to give. At present a small cooperative study (with the U. S. Fish and Wildlife Service) on the influence of pocket gophers on subalpine vegetation is under way in central Utah. Parts of several exclosures on desert range in Nevada are built to exclude small mammals as well as livestock, and data collected on these in 1947 are in process of analysis.

The coverage of these studies is very incomplete. Construction of pastures, as at Dubois and the Desert, cannot be carried very rapidly into other areas because initial costs are high and maintenance becomes a burden. Broader areal coverage by studies on the influence of animals will very likely be achieved for many years to come only by extensive studies and exclosure comparisons.

Control of undesirable plants

Undesirable plants that have increased on Intermountain ranges include sagebrush, cheatgrass, tarweed, pinyon-juniper, and a number of poisonous species such as Halogeton, larkspur, lupine, and sneezeweed. Procedures for the control of some of these species are known. Much progress has been made in the use of fire and mechanical methods in eradicating sagebrush so as to increase the production of herbaceous vegetation. Simply lessening the intensity of grazing on sagebrush range will ultimately produce results, but because of the longevity of sagebrush, the trend toward improvement is slow.

Where pinyon and juniper have invaded sites with deep soil, such improvement is likely to be even slower, for the trees will evidently outlive many generations of men. Where ground fuels are sufficiently abundant fire would appear to be a solution. So little research has been done on the ecology of this important type, however, that a discussion of control at this time is premature.

On the other hand a lessening of grazing intensity to encourage native perennial herbs and grasses, perhaps coupled with spraying along roadsides and around corrals, may be a practical solution to the Halogeton problem. At any rate Russianthistle, which appears to be similar to Halogeton in growth form and requirements, has been practically eliminated under moderate grazing, as compared with heavy grazing, on salt-desert types. Probably a small, short-term study of the Halogeton problem would yield the information necessary to make practical recommendations for control of this deadly weed.

A problem has arisen concerning the eradication of blackbrush (Coleogyne) which covers vast areas in southern Nevada and Utah, sometimes to the virtual exclusion of other vegetation. Some people have become convinced that blackbrush should be burned off to encourage herbaceous vegetation, and without much knowledge about the ultimate consequences, in terms either of range vegetation or watershed cover, large-scale burning has begun. At the request of the Bureau of Land Management members of the Intermountain Station have inspected burns in southern Nevada. Our conclusion has been that there is no easy answer to the question of blackbrush burning. In some areas there appear to be benefits--a very marked increase of forage (this is the inducement for burning) and little erosion hazard. In other areas there may be an immediate increase in forage, but long-time forage values are damaged and erosion is very greatly increased. A great variety of combinations of effects has been observed. The pressures for burning are strong, and it is possible that grave and costly damage may be done, in the form of soil erosion and reservoir siltation, if burning is continued blindly as it has been in the past. Thoroughgoing research on the ecology of blackbrush in the great variety of sites in which it grows, and the response of blackbrush and associated vegetation to fire, together with the effects of burning on soil erosion, is very urgently needed.

Undoubtedly the most perplexing and important undesirable plant is cheatgrass. Aided by fire, cheatgrass is dominating more and more territory every year in northern Nevada and northern Utah, and particularly in southern Idaho. Its area of dominance is increasing year by year, and with repeated fire its suppression of native vegetation--perennial grasses, herbs, shrubs, and even trees--becomes more and more absolute. Spreading from abandoned dry farms it has swept in the wake of fires over vast areas of sagebrush-grass range up into the foothills, superseding mountain brush, thus limiting game winter range in places, and pushing timber back up the slopes. Drying out like tinder in summer, cheatgrass is a precursor of ever more frequent fires, and with each fire the chances for recovery by perennial species become less and less. Thus to all intents and purposes the spread of cheatgrass is irreversible. Whatever its merits, cheatgrass is tinder for another fire and because it thus destroys perennial vegetation in its path and bares the ground to accelerated erosion, its spread is an ecological catastrophe.

A beginning has been made in learning how to reseed perennials into cheatgrass successfully. Because of cost, artificial reseeding can be only a small part of the answer, however. Something that is cheaper and that is applicable on a wider scale is needed, and the way to such a solution, if there is a solution, lies in a better understanding of cheatgrass and the environment in which it is spreading--in other words basic ecological research. This research should begin on the advancing cheatgrass front to determine the factors that encourage and that hinder cheatgrass, and how these factors affect native vegetation. It should include studies of the growth requirements of cheatgrass in relation to those of native species. Both on this advancing front and where cheatgrass is already dominant this research should include an appraisal of the effects of grazing management on reinvasion of perennials, maintenance of the cheatgrass forage crop, and fire hazard.

RANGE MANAGEMENT RESEARCH PROGRAM

Present Effort

In order to understand our present research effort a thumbnail sketch of the background for each of the five projects will be included. Because range livestock grazing in this region is seasonal, the first three grazing management projects activated at the Intermountain Station were called Summer, Spring-Fall, and Winter Range studies. The Utilization Standards Project came into the picture in the late 30's, and the Big Game-Livestock Range Relationship Project, which concerns itself with deer in Utah, in 1946.

Summer Range

Summer range research begin at the Great Basin Branch Station near Ephraim, Utah, about 1911, and we are still following changes in vegetation there on permanent plots that were established in 1913. Most summer range studies have been confined to this locality. Relations between weather and plant growth, variation in climate with topography, microclimate, relations between plant cover and erosion, influences of pocket gophers, carbohydrate translocation in forage plants, and indicators of condition and trend, have been the main interests in this project. Most of the studies are conducted either on open range or on areas protected entirely from grazing. At present a joint manuscript with the Watershed Management Division "Indicators of Condition and Trend on High Range-Watersheds of the Intermountain Region" is in process of Departmental publication. An extensive ecological study of the subalpine zone of the Wasatch Plateau has recently been completed. This study, utilizing old photographs, study plots, and all available natural areas, is an attempt to classify the plant communities and to trace the courses of primary and secondary succession. The highlights of this study are given in the Intermountain Station Annual Report for 1947, and the full report is now being prepared for publication.

At present Summer Range studies are virtually at a standstill for lack of personnel.

Spring-Fall Range (Two men)

Studies of spring-fall ranges of southern Idaho were begun at the U. S. Sheep Experiment Station near Dubois in 1923. The main effort here has been with sheep in pasture studies, and aspects of these studies have been reported. In 1941 a grazing intensity study was begun under a rotation plan. This has now gone through two complete 4-year rotations. The pastures were inventoried in 1949, and the data are now being compiled and analyzed.

The use of fire for range improvement in removing sagebrush has been studied for a good many years at the Sheep Station. The results of these studies have been reported in a Farmers' Bulletin, but the detailed ecological results of burning have not as yet been reported. In 1948 a reinventory was made of a controlled burn on which experimental plots had been established in 1932. The data from this reinventory are currently being analyzed.

In addition to these two studies there are many data in the project files which need to be analyzed and reported on. In order to move this work of compilation and analysis along as rapidly as possible, field work is being kept to a bare minimum for the next two or three years.

Winter Range (Two men)

In 1933 the Desert Experimental Range was established 50 miles west of Milford, Utah, to provide information for formulating standards of management and proper use on winter range. Studies were begun on utilization, grazing capacity, herbage yield, plant growth, and watering livestock; and in addition sheep and wool weights were obtained to determine the effects of management practices on animal production. A manuscript has been submitted for publication as a Departmental Circular covering these studies and entitled, "Management of Winter Sheep Ranges in the Intermountain Region."

A series of large exclosures was established in Nevada and parts of Utah in the period 1936 to 1941. Plots inside these exclosures and outside have been examined at roughly 5-year intervals. One of the major jobs that needs doing at present is analysis of the accumulated data from these areas.

In addition, there is a considerable body of accumulated data on the Winter Range Project which has not yet been analyzed. As with the Spring-Fall Project, field work on winter range is being held to a bare minimum in order to give as much time as possible to analysis of data and preparation of manuscripts.

Utilization Standards (One man)

Most of the work of the Utilization Standards Project has been carried on in the vicinity of the Great Basin Branch Station near Ephraim. This work has been concerned with growth form and measurement of forage utilization, and with an attempt to relate plant vigor to intensity of grazing.

In the past few years the work of the Utilization Standards Project has been redirected to a study of condition and trend. The aspen type in Utah was selected for this study because its grazing potential appeared to be high, general depletion was advanced, and little was known about the type. A good many facts have been learned about the aspen type which should be of considerable help to Administration in management. However, progress has been slow in organizing this material partly because of shifts in personnel. It is hoped to get out a guide, at least in preliminary form, for the use of the region by next year.

Field observation suggests that key areas in management may be the openings in the aspen type, and one of the questions that needs to be answered in judging condition concerns the productivity of vegetation in openings as compared with that of vegetation beneath the aspen canopy. Extensive observation has not provided answers to this question, and therefore a short-term experiment is being performed in which the production of several native species will be measured in both environments.

Big Game-Livestock Range Relationships (Two men)

This is a cooperative project involving, besides the Intermountain Station, the Fish and Wildlife Service, Utah State Fish and Game Department, and Utah State Agricultural College and Experiment Station. The Bureau of Land Management and Forest Service Administration cooperate in a consultive capacity.

This project is rather extensive in that a number of study areas throughout Utah are being used. The chief of these are near Oak City on deer-cattle range and near Richfield on deer-sheep range.

Our participation is confined for the present to relationships between deer and livestock. Deer problems appear to be much more urgent and widespread than those involving elk or antelope. Until now most of the effort has been on food-habit relationships.

This project has been working on a detailed problem analysis since it was activated. We hope to complete this problem analysis soon and utilize it in orienting the future research program. Another effort has been to prepare a popular bulletin describing the deer-livestock problem, the facts that are known, and the sort of information that is needed. This will, we hope, be published by the Utah State Fish and Game Department. Such a bulletin should fill a real need, for the lack of understanding about game range on the part of the general public is a serious barrier to better management.

Four general problems of high priority have been outlined. How well does our research effort accord with these?

The work of all projects contributes to the ecological basis for management (p. 10). However, effort in only one--Summer Range, now largely inactive--is directed particularly toward the specific and urgent problem of ascertaining the character of normal vegetation and normal soil erosion.

All projects are involved in the problem of determining range condition and trend (p.11), but of the many vegetal types in the region only a few have received much attention. These include sagebrush-grass in southeastern Idaho, aspen and subalpine upland-herb in central Utah, and shadscale-winterfat in western Utah.

All projects are concerned, similarly, with the influence of animals in the range complex (p.11), but the detailed studies that have been made are few: sheep on sagebrush-grass and on shadscale-winterfat types, cattle in a mountain brush type, and deer-sheep and deer-cattle relationships. A small study is also under way on the effects of pocket gophers on subalpine grassland.

Most projects have done some work with problems created by undesirable plants (p. 12). Except for sagebrush, little study has been made of undesirable plants, and our progress in control has been slight. We have observed, as with blackbrush burning in southern Nevada, what appear to be misguided efforts at range improvement through burning, but have not been able to do the research needed either to guide burning into constructive channels or to demonstrate its undesirable effects. The most important problem plant of all--cheatgrass--is receiving virtually no attention, either from us or from anyone else, in the way of ecological research.

How well does our research effort accord with the three problem areas considered to have highest priority? Frankly, not very well.

Field work on mountain grasslands (p. 9) is almost at a standstill, except for condition and trend in the aspen type. (This is concerned, as research in timber and brush types must be, with herbaceous vegetation in openings even more than with understory vegetation.) Yet national-forest administrators are asking for information to assist in solving practical management problems. They want to know the productive potential for specific kinds of range, what degree of cover and what vegetal composition to aim for in management. They want to know how specific ranges should be classified as to condition, what the indicators of trend are on these ranges, and how to read them. They want to know how much forage utilization is permissible, and what plants to use as key species in judgment of utilization. They want to know how to tell when erosion is normal and when it is accelerated. They want to know what the effects of rodents are on the range, and how to tell utilization by deer and elk from utilization by sheep and cattle. Information of this kind and on the scale needed requires ecological research far beyond our present power to supply. One resource that can be exploited as our effort on mountain range land is increased are the exclosures and study plots that have been established in past years, many of which have been abandoned. Some of the study plots have been lost or the original records are worthless, but experience has shown that there are also some that can be made to yield worthwhile information.

Although very little management research is being done in the Colorado River basin (p. 9), and that little only at high elevations, there is a possibility of shifting emphasis in that direction. Some attention can probably be given the low-lying desert types within the basin by personnel of the Winter Range Project, and some attention can probably be given mountain brush and pinyon-juniper types, insofar as grazing by big game is concerned, by personnel of the Big Game-Livestock Range Relationships Project. Other exploratory studies are planned in 1950 to ascertain where protected areas exist that can be used in setting up standards for judgment of range condition and trend. These efforts are far from an adequate research program, but they should be helpful for Flood Control Surveys, and will at least provide a basis for planning research when a program is ultimately financed.

No ecological work is being done on granitic soils in southwestern Idaho (p. 9). This activity could readily be correlated with an ecological study of cheatgrass in that area if manpower were available. A large number of plots and quadrats, established about 20 years ago and carefully studied for about 10 years, together with several exclosures, are available to get this research off to a good start.

This problem area of granitic soils and the first one listed above, that of areas of herbaceous vegetation in the mountains, are not mutually exclusive: in southwestern Idaho they overlap. This fact, taken together with the opportunity to work on the very important cheatgrass problem in the same general area, the availability of a series of established study plots, and the facilities of the Boise Basin Branch Station, gives this problem area highest priority. If funds become available for additional range-management research, they should be applied first in southwestern Idaho. On the other hand, if our research continues to be financed at its present level, southwestern Idaho could perhaps best be served, with least loss to our total research effort, by shifting the two men there who are now doing range management research at the U. S. Sheep Experiment Station. This could not be done for several years, however, until the results of long-time experiments at the sheep station are analyzed and reported on.

PROGRAM FOR 1950

Summer Range (Ellison)

1. Complete revision of manuscript covering fundamental ecological studies, "Subalpine Vegetation of Wasatch Plateau, Utah."

2. Reinventory vegetation on pocket-gopher plots at head of Ephraim Canyon and prepare vegetal phase of joint report with Fish and Wildlife Service.

3. Participate in inspections of Colorado River basin.

4. Assist Region in training meeting.

5. Assist Parker in condition and trend study.

Spring-Fall Range (Blaisdell, Mueggler)

1. Complete preparation of manuscripts, "Effects of Controlled Burning of Sagebrush-Grass Range on the Upper Snake River Plains" and "Effects of Spring and Fall Grazing by Sheep on Vegetation of the Upper Snake River Plains."

2. Analyze data from two 4-year rotations of pasture study and (jointly with University of Idaho) from chemical analyses of forage plants, and prepare reports.

3. Continue routine grazing treatments of pastures, collecting utilization data and minimum plot records.

Winter Range (Hutchings, McGinnies)

1. Complete preparation of manuscripts, "Management of Winter Sheep Ranges in the Intermountain Region," and "Deer Utilization of Oakbrush Range."

2. Prepare report, cooperatively with University of Nevada, on vegetation inside and outside Nevada exclosures.

3. Participate in inspection of Colorado River basin.

4. Continue grazing treatments of pastures at a maintenance level.

Utilization Standards (Houston)

1. Prepare Station Research Paper on indicators for judging condition and trend in aspen type.

2. Reexamine old plots and quadrats in aspen type.

3. Lay out experiment to test productivity of range in openings as compared with that under aspen canopy as a basis for more accurate judgment of condition and trend.

4. Assist Parker in condition and trend study.

Big Game-Livestock Range Relationships (Julander, Smith)

1. Complete manuscript (cooperatively with Fish and Wildlife Service, Utah State Fish and Game Department, and Utah State Agricultural College), "Range for Game and Livestock in Utah."

2. Complete project problem analysis.

3. Complete food-habit studies and prepare reports.

4. Begin studies on condition, trend, and utilization standards on big game range, giving particular emphasis to mountain brush type where Administration is greatly in need of such information, both for livestock and big game.

5. Participate in inspection of Colorado River basin.

RESEARCH IN RANGE RESEEDING

RESEEDING IN THE COLORADO RIVER BASIN

Wildlands total 97 percent of the Colorado Basin, of which it will perhaps be feasible, when suitable species and methods are known, to reseed some 10 percent. The remaining grazable wildlands must be improved or maintained by some form of extensive management. The reseeded lands, after a stand is produced, must also be conservatively grazed lest the new plant cover be damaged and thereby fail to stabilize the soil.

The problem of improving plant cover in the Colorado Basin by range reseeding is intricate, complicated by widely different kinds of soil, by variations in amount and distribution of precipitation, and by the degree of damage the plant cover has suffered from previous grazing use. Reseeding is further complicated by the unequal amount of information available for handling the land in various vegetal zones of the basin. There are, however, certain basic procedures and principles that we have learned which are applicable wherever similar sets of conditions obtain. Thus, information gathered on a site in central Utah will be pertinent on a site in the Colorado Basin where corresponding conditions exist. A key to comparability of conditions is, fortunately, provided by many comparable plant cover subtypes in the Colorado Basin and in other parts of the Intermountain region.

Most studies up to now have been made in the Great Basin, but a number are just over the divide from the headwaters of the Colorado. All are on vegetal types that occur in the Colorado Basin. Enough data for the sagebrush, mountain brush, and aspen have been collected to develop seeding programs in these types. Pilot plantings are needed and could be put out quickly. For the subalpine zone only a part of the needed information is available. Other vegetal types that occur in southern Utah also need attention. Among these are blackbrush (Coleogyne) and sand sage (Artemisia filifolia). There are also considerable areas of desert grassland with deteriorated plant cover in southeastern Utah on which reseeding studies are required before a program of seeding can be started.

The most serious deficiencies in knowledge are in the salt-desert shrub and pinyon-juniper zones. Both are heavy silt contributors and cover extensive areas in the Colorado Basin. Studies on species adaptability and methods in these zones are urgently needed.

During the last two years considerable emphasis has been given to experimental studies in the Colorado River basin itself. On the east drainage of the LaSal division of the Manti National Forest in southeastern Utah approximately 300 plots to study species adaptability and methods have been established. A total of about 20 selected species are being tested in juniper-pinyon, mountain brush, and aspen types. A comparative study of seeding various species with earthen pellets by airplane and by standard ground methods has been conducted in this area.

Observations have shown that areas within the above types can be markedly improved by artificial seeding. Techniques and species which have proved successful on similar types within the Great Basin area appear suitable here. In fact, preliminary experimental results and large-scale forest seedings show that on comparable sites good stands are easier to obtain than in the Great Basin on account of greater summer precipitation and generally greater depletion of competing plants.

From research in the subalpine zone within the Colorado drainage and elsewhere procedures have been developed for rehabilitating some of these high areas. Exploratory studies were established four years ago on a shadscale site near Ferron, Utah, typical of much desert country in the Colorado River basin. Here annual precipitation is between 7 and 8 inches. Crested wheatgrass was the most successful species, and good stands of this grass could likely be established during the moister years. Undoubtedly there are other species such as common winterfat (*Eurotia lanata*), fourwing saltbush (*Atriplex canescens*), and Indian ricegrass (*Oryzopsis hymenoides*) that would be useful on many of the desert sections of the Colorado River basin, but technique to get dependable germination and early establishment needs developing. Plant selection should prove helpful in this respect.

Plans for 1950

During 1950 pilot plantings will be made in all major zones in the Colorado Basin preparatory to action seeding. In addition, study plots of species suitability and methods of removing competitive plant cover and seeding will be started in the salt-desert shrub and pinyon-juniper types.

METHODS OF SEEDING AND REMOVING COMPETITION

Airplane pellet seeding

A study of airplane seeding with pelleted and unpelleted seed was begun on the LaSal Division of the Manti National Forest in 1948. Details on seeding methods and site characteristics were given in last year's annual report.

Extensive seedling counts were made from June 21 to July 15, 1949. Table 1 presents combined averages for all study plots on each of the four vegetal types in which the airplane broadcasting was done. These combined averages show that unpelleted seed produced from 18 to 75 times as many grass seedlings as pelleted seed, depending on the planting site and other factors.

Intensive plot studies. In addition to the large-area airplane broadcasting, several plots were established in areas representative of the major types. These plots were variously plowed, harrowed, brush-dragged, and burned. Seeding treatment consisted of aerial broadcasting

Table 1. Average numbers of seedlings per square foot in four vegetal types with different seeding rates and methods[1]

Type	One pellet per sq. ft.	Two pellets per sq. ft.	Unpelleted seed
Aspen	.38	--	9.41
Ponderosa pine	.23	.25	7.44
Mountain brush	.02	.02	1.51
Pinyon-juniper	.12	.18	3.30

[1] One pellet per square foot equals approximately 1.2 pounds, and two pellets 2.4 pounds of seed per acre. Unpelleted seed was broadcast at 10 pounds per acre.

of pelleted and unpelleted seed and hand broadcasting of unpelleted seed. Data on the seedling stands which resulted are summarized in table 2.

Table 2. Average numbers of seedlings per square foot in four vegetal types with various treatments and different methods[1]

Vegetal type and treatment	Aerial broadcast			Hand broadcast
	One pellet per sq. ft.	Two pellets per sq. ft.	Unpelleted seed	Unpelleted seed
	Number seedlings per square foot			
Mountain brush				
Plowed	.15	.22	6.16	[2]2.88
Harrowed	.08	.11	4.40	[2]3.36
No treatment	.05	.06	2.26	[2]3.32
Burned	.06	.25	1.58	[2]2.01
Pinyon-juniper				
Brush dragged	.18	--	--	2.80
No treatment	.12	.30	--	--
Ponderosa pine				
Harrowed	.29	--	--	19.99
No treatment	.20	.36	--	--

[1] One pellet per square foot equals approximately 1.2 pounds, and two pellets 2.4 pounds of seed per acre. Unpelleted seed was broadcast at 10 pounds per acre.

[2] Harrowed after planting (Note that the additional harrowing on plowed and harrowed ground probably buried the seed too deeply. With no soil disturbance prior to sowing, harrowing improved the results, probably by helping to cover the seed.)

For any treatment within a type the seedling stands from unpelleted seed were far superior to those obtained from ~~un~~pelleted seed. For example, the aerial broadcasting of unpelleted seed in the mountain brush type gave from 6 to 44 times the number of grass seedlings given by pelleted seed sown at two pellets per square foot.

Chemical sprays for removing competition

Selective sprays such as 2,4-D and 2,4,5-T offer great hope in the artificial revegetation program. Three distinct uses are immediately discernible: (1) for the removal of undesirable shrubs such as sagebrush (*Artemisia*) and rabbitbrush (*Chrysothamnus*) where there is a good stand of native grasses; (2) for the destruction of shrubs prior to reseeding; or (3) for the elimination of shrubs invading a reseeded stand of grass.

Control of brush to release native grasses. On an area of native range which has not been reseeded on the Dixie National Forest, the vegetation present in greatest abundance was big sagebrush (*Artemisia tridentata*), rubber rabbitbrush (*Chrysothamnus nauseosus*), jimmyweed (*Aplopappus heterophyllus*) and juniper (*Juniperus*). Native grasses were principally slender wheatgrass (*Agropyron trachycaulum*) with bluestem wheatgrass (*A. smithii*) prevalent in swales and bottoms. Test plots were marked out and sprayed with 2,4-D in various concentrations and with mixtures of 2,4-D and 2,4,5-T. These sprayings were completed in June 1949 while the shrubs were still growing actively. Examination in August 1949 indicated that the shrubs were adversely affected by the spray.

Control of undesirable vegetation prior to reseeding. On West Camas Creek, Targhee National Forest, there is a dense stand of wyethia (*Wyethia*) with small amounts of bluegrass (*Poa*), fescue (*Festuca*), sedge (*Carex*), slender wheatgrass, mountain brome (*Bromus carinatus*), dandelion (*Taraxacum*), dock (*Rumex*), etc. with some black sagebrush (*Artemisia nova*) and big sagebrush on higher ground. A series of plots with checks has been laid out and sprayed with various concentrations and mixtures of 2,4-D, 2,4,5-T. Half of these sprayings were done on June 7 and the others on June 20, 1949. One replication will be left without further treatment to determine what recovery can be expected from natural vegetation following wyethia eradication. The other replication was drilled to a mixture of grass species in the fall of 1949.

At Paradise Valley, Nevada, a mixture of 2,4-D and 2,4,5-T was sprayed on separate plots of big sagebrush, black sagebrush, and greasewood (*Sarcobatus vermiculatus*) in May 1949. Inspection of these plots in June 1949 revealed that both sagebrushes were nearly completely withered, and that the greasewood was dry and brown.

Control of shrubs in reseeded areas. At Moon Canyon on the Wasatch National Forest an experiment was begun in 1947 to determine the effect of 2,4-D on rabbitbrush and sagebrush on reseeded range land. By 1949

93.8 percent of the sagebrush was apparently dead and 6.2 percent was badly injured. The sprayed rabbitbrush showed 90.7 percent apparently dead, 5.5 percent badly injured, and 3.8 percent with little injury.

Grass yields on the sprayed plots were noticeably higher than on the unsprayed check plots. Weight estimates of the yields of air-dry forage (grass) in pounds per acre for 1948 and 1949 on the sprayed and unsprayed plots are shown in table 3. Not only were the grasses producing a heavier yield on the sprayed plots, but they were taller, greener, and entirely unmarked by the spray treatment.

Table 3. Yields of grass in pounds per acre (dry weight) on plots sprayed with 2,4-D in 1947

	1948	1949	Average
Sprayed plots	2,350	5,700	4,000
Unsprayed check	1,800	2,400	2,100

In 1942 the Linford area of the Pines reseeding tract on the Dixie National Forest was wheatland plowed and drilled to a mixture consisting chiefly of crested wheatgrass (Agropyron cristatum), but including smooth brome (Bromus inermis), orchardgrass (Dactylis glomerata), and bulbous bluegrass (Poa bulbosa). A good stand of grass resulted. At the same time, however, young plants of rubber rabbitbrush also became established and by 1949 rabbitbrush standing from 30 to 48 inches tall dominated the site. There was a good understory of grass, but it was not available to livestock owing to the density of the rabbitbrush.

Spraying treatments consisting of various concentrations of 2,4-D and mixtures of 2,4-D and 2,4,5-T were applied in June 1949. Observations in August 1949 showed that the rabbitbrush was strongly affected by the spray, but the extent of control cannot be determined until 1950.

Plans for 1950

Another set of seedling observations will be made on the pellet seeding experiments and the project closed. Studies of brush control in native and reseeded stands with chemicals and other means will be continued and extended to juniper. The effectiveness and relative cost of brush removal with the brushland plow will be continued on R-4 plantings. Research in salt-desert shrub types will be prosecuted as to methods, time, and rate of seeding.

SPECIES ADAPTABILITY

Subalpine zone, northern Nevada

New experimental plantings were made in snow bank areas of the high mountains of northern Nevada where snow remains until late in the growing season. Vegetation on these sites is green and succulent after that of the surrounding country has reached maturity, attracting stock when the soil is slushy wet. Great damage is done by the almost complete removal of vegetation, severe trampling, and consequent erosion. Series of small plots were arranged on the contour in these "sore" spots and were planted to a variety of vigorous sod-forming grasses.

Other experimental plantings were made on the broad types of range land found above 7,000 feet elevation in the mountains of northern and eastern Nevada. Studies of species adaptability were begun in high-mountain types of big sagebrush, black sagebrush, serviceberry (Amelanchier alnifolia), mountainmahogany (Cercocarpus ledifolius), and golden quaking aspen (Populus tremuloides aurea).

Subalpine zone, central Utah

Species plantings in subalpine ranges show that many summer grazing lands in Utah can be returned to much higher production and that at the same time the soil can be stabilized. On relatively large sections, production from natural cover is less than 500 pounds green forage per acre. When reseeded species are established, forage yields on extensive acreages can be increased to as much as 2,000 pounds per acre, and on the better soil types to more than 5,000 pounds.

Yields were recorded for 1949 from a series of range plots sown in the spring of 1947 on a formerly depleted area at about 10,000 feet elevation. The Tualatin strain of tall oatgrass yielded 4,875 pounds and the commercial strain yielded 4,150 pounds of air-dry forage per acre. Smooth brome yielded 3,463 and mountain brome 3,000 pounds of air-dry forage per acre. Quackgrass and Reed canarygrass yielded 2,788 and 2,700 pounds of air-dry forage per acre respectively. Alsike clover and alfalfa were the highest yielders of the legumes and broadleaf species.

Subalpine zone, central Idaho

In 1949 species adaptability studies were begun on four different kinds of sites in the subalpine zone on the Boise and Challis National Forests: (1) On a harsh, treeless, south-facing slope of loose granitic soil at an elevation of about 8,000 feet plantings were made to determine whether intense insolation can be advantageously modified by a light mulch of pine boughs. (2) Seeds were broadcast on the ashes of a fresh burn in lodgepole pine to study the relative usefulness of various species for reseeding on burns at different elevations and on different soil types. (3) Plantings were made on depleted mountain meadows to determine species that might be used to increase the forage production of these lands which are now occupied by low-value weeds and grasses. Studies of methods of eradicating the present vegetation and of seeding the more desirable species were made in conjunction with the species adaptability studies. (4) In cooperation with the Challis, 30 species were sown in plots in Copper Basin. This cattle range has a fair to good cover of grass and an abundance of sagebrush, but the grasses are low growing and generally not considered desirable forage species.

Kochia for revegetation

Much interest has been shown in kochia (*Kochia scoparia*), a herbaceous annual of the saltbush family. This plant was grown at several different sites in central Utah near Ephraim and proved to be adapted to soils showing a rather high degree of salinity. Kochia appears to be especially well adapted and productive on those lands where a high water table exists during the growing season. It is a prolific seed producer and grows well as a volunteer stand if not too thick.

On a dry, rocky valley bench with an annual precipitation of 11 inches, kochia produced 1,000 pounds of dry herbage per acre. In an opening in the oakbrush with 14 inches of precipitation it yielded 1,600 pounds per acre. This, and the fact that kochia when irrigated twice produced up to 8,000 pounds of air-dry forage per acre on soil too salty for any common crop, suggests wide possibilities in the Intermountain region. Seed yields of 2,000 pounds per acre are also recorded under irrigated conditions. Kochia has been found to be very palatable, either as green pasture or cut as hay, for both cattle and sheep. Its nutritional value compares favorably with that of alfalfa, from analyses made by the Utah State Agricultural Experiment Station (table 4).

Table 4. Nutrient composition of kochia in three stages of development compared with alfalfa hay

Species and stage of growth	Total protein	Fats	Ash	Fiber	Nitrogen free extract
Kochia - 17 inches high, no flowers showing - June 17	22.99	1.74	23.27	16.10	35.90
Kochia - 60 inches high, seed forming - July 23	17.71	2.56	14.50	28.83	36.40
Kochia - 65 inches high, seed nearly mature - September 11	12.64	3.97	11.55	29.04	42.80
Alfalfa hay	16.26	2.21	9.18	32.08	40.27

Seed supply

Certain grasses that have been recently introduced show great promise in experimental plots and field trials. The shortage of seed and, in many cases, resulting high prices have prohibited their inclusion in some plantings for which they were well suited. Because of this situation the Station has encouraged local seed production of these species. Administration has planted some areas for seed harvest and private growers have also responded to this call.

On a farm in the lowlands of central Utah near Ephraim, several species of grass were planted on land having from 850 to 3,800 parts per million of soluble salts. Planted in the spring of 1944, these grasses were producing seed in 1945. Some of the most successful species yielded seed in 1949 as follows (in pounds per acre): tall (Alta) fescue (*Festuca elatior arundinacea*) from 960 to 1,100, tall wheatgrass (*Agropyron elongatum*) from 747 to 920, smooth brome from 377 to 1,159, crested wheatgrass 28 from 297 to 973, tall oatgrass from 295 to 737, and slender wheatgrass from 210 to 579.

Revegetation for big game

Within the Intermountain region many valleys formerly used by wintering big game herds are now farmed and the valley fringes (usually borderline between sagebrush and mountain brush) are depleted. Consequently, herds of deer and elk which are forced down from their mountainous summer range by winter snows encroach on cultivated fields, orchards, and haystacks. Experience has shown that where browse species are abundant, big game herds are successful in enduring severe winters without recourse to orchards or haystacks.

South-facing slopes along the South Fork of the Payette and Boise Rivers constitute an important segment of the winter range for deer and elk. The present annual forage production of browse species on these slopes is only a fraction of what it was formerly. Insect infestations, heavy use by game and livestock, fires, and possibly other factors, have seriously reduced the vigor of bitterbrush (*Purshia tridentata*), in places almost completely destroying it as well as other valuable forage species. The low vigor and irregular distribution of the few old shrubs still living is such that they cannot be depended upon as sources of seed for early natural reestablishment of this valuable species.

A cooperative agreement between the Idaho Fish and Game Department, the Boise National Forest, and the Intermountain Station was made in 1949, and research was started. Seeds of a number of native browse species were collected for experimental planting. Intensive observations were made on all available plantings of browse species with particular attention to bitterbrush, and native bitterbrush stands were examined to determine the age and position of seedlings in relation to mature plants and herbaceous vegetation. Plantings were made to determine the adaptability of 33 species of shrubs and 18 grasses, and seed of bitterbrush from various sources was planted. Other factors being investigated are optimum depth for sowing bitterbrush and influence of the present annual vegetation upon survival of bitterbrush seedlings.

Near Ogden a cooperative agreement was also entered into by the Intermountain Station, Cache National Forest, Utah Fish and Game Department, and Weber County Wildlife Federation. Members of the Weber County Wildlife Federation constructed two enclosures in an area where deer concentrate in winter. One was made of woven wire to a height of 8 feet, designed to exclude deer as well as livestock; the other was lower, so as to permit easy access by deer, but to exclude cattle.

Factors to be recorded and analyzed include capacity of species to become established from seed, ability to make thrifty growth under existing site conditions, extent of natural reproduction after being started artificially, and degree of palatability to big game.

Plans for 1950

The most promising of previously tried species and all new species obtained will be tested in all zones. A special effort will be put forth to obtain and test species suitable to the salt-desert zone in the Great Basin and Colorado Basin, to the subalpine zone, and to granitic soils of southwestern Idaho.

SITE FACTORS

Seedling emergence and survival

A study was made of seedling emergence and survival with 16 grasses in the mountain-oakbrush zone (elevation 7,200 feet) and in the valley-sagebrush zone (elevation 5,500 feet) in central Utah. Replicated plots of the grasses were planted at both sites in early fall (October 10-13), late fall (December 4-16), and spring (April 4-21). The early fall plantings showed the highest total seedling emergence at both sites (table 5). The spring plantings were next highest, and the late fall plantings showed the lowest proportion of seedling emergence.

Table 5. Seedling emergence and percent survival from early fall, late fall, and spring plantings in valley-sagebrush and mountain-oakbrush sites

	Valley-sagebrush site			Mountain-oakbrush site		
	Early fall	Late fall	Spring	Early fall	Late fall	Spring
Percent emergence	66.2	24.8	35.8	56.1	29.7	39.7
Percent survival of emerged seed	8.2	28.4	10.3	27.4	48.5	48.0
Seedling survival as percent of viable seed	5.4	7.0	3.7	15.3	14.4	19.0

There was a high mortality in these newly emerged seedlings, highest in the early fall plantings at both sites, and lowest in the late fall plantings. For all three planting dates seedling survival in the mountain-oakbrush site was two to five times greater than in the valley-sagebrush site.

Site factor studies in Idaho

For several years range seedings made on loose granitic soils of southwestern Idaho have failed to become established. In some cases good germination was obtained but plants died during the protracted dry summer period. (Once grass plants become established on these sites, however, they grow and thrive for many years.) In an effort to overcome this failure in establishment three series of experiments involving use of mulches, fertilizer, specially chosen species, and methods of removing old vegetation, were set out in 1949. Because the spring and summer were unusually dry in 1949, the results will not be known until the spring or perhaps the autumn of 1950.

Site evaluation

Herbage yields from selected crested wheatgrass plots are being recorded from year to year. The most important site factors at each plot are studied and noted. Such surface features as soil color, percent of organic carbon, amount of erosion pavement, surface litter, degree of erosion, exposure and slope, altitude, and latitude are being evaluated. Subsurface features which are being studied include depth and texture of A horizon, depth to hardpan or claypan, and water-holding capacity. Natural plant cover features which are studied and recorded include aggregate height of dominant species (usually big sagebrush), crown closure of dominant species, and other species present.

When sufficient data have been collected a correlation will be worked out between site factors and yield. This information should enable a field worker to predict the degree of success to be expected in establishing a stand of crested wheatgrass and approximate the eventual herbage yield on any given site that is to be reseeded.

Plans for 1950

The following studies on site factors will be prosecuted with as much vigor as funds and personnel permit:

1. How to restore plant cover on the loose granitic soils of southwestern Idaho.

2. How to evaluate potential forage and cover production of various kinds of soil in different locations in the sagebrush and mountain brush zones.

3. What restoration of plant cover and forage can be obtained in various sites in the subalpine and spruce-fir zones.

PLANT BREEDING AND STRAIN STUDIES

The plant-breeding line project is conducted in cooperation with the Forage Crops office of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and with the support of the Nursery Division of the Soil Conservation Service. There are two phases to the project: (1) production of strains by introduction, selection, and controlled pollination; and (2) testing under range conditions of promising strains for yield and other desirable forage qualities. Dr. Wesley Keller conducts the local grass breeding work at Logan, Utah, and furnishes strains for range trials. He also accepts from the Intermountain Station suggestions as to valuable range material.

Testing the strains under range conditions is done by the Intermountain Station mainly at the Majors Flat nursery in Ephraim Canyon. More than 300 strains are now under trial. This collection is made up of strains from grass breeding nurseries of the Bureau of Plant Industry, from the introduction nurseries of the Soil Conservation Service, from a considerable number of strains obtained from various geographic localities in western America, from selections made locally, and from some foreign introductions. New strains are being added currently. Many of the older strains have been under test long enough to prove their value. Some of them are three to five times superior in yield to others and much superior to the stock varieties. The 1946 report gave many details about strains obtained several years ago. The newly received ones require three or four years in which to establish their comparative value in yield, palatability, longevity, winter hardiness, and drought resistance.

In July 1949 the grass breeders (BPISAE) working in western United States held a conference at Logan, to which the Station sent a representative. As a result of the contact, some 50 additional strains were obtained. The group was also made acquainted with the Station's seeds for range forages and some of the members were conducted on a tour to several reseeding plantations. Since that time the Station has received letters of inquiry and information, indicating that an effective cooperation has begun.

Plans for 1950

Contact with grass-breeding groups and plant introduction agencies will be maintained in order to receive promising new strains. Active cooperation with BPISAE will be continued. Strain testing at the Great Basin will be prosecuted as vigorously as funds and personnel permit.

UTILIZATION

Cattle grazing - Benmore

The Benmore experimental grazing studies, described rather fully in previous reports (1947, 1948), were continued in 1949, cooperatively with the Utah Agricultural Experiment Station and the Soil Conservation Service. The experiment is being conducted on 24 pastures of 100 acres each, divided into two blocks of 12 pastures. The two blocks include four methods of grazing at light, moderate, and heavy intensities, as follows:

All spring - continuous	Light	Moderate	Heavy
All spring - rotation	Light	Moderate	Heavy
10 days deferred	Light	Moderate	Heavy
10 days short at end	Light	Moderate	Heavy

During 1949, the planned intensities of grazing of 50, 65, and 80 percent use for light, moderate, and heavy intensities were achieved rather closely. The average of eight pastures for each intensity showed 50.5, 64.9, and 77.8 percent use.

In 1949, with spring precipitation somewhat more than average, dry-weight yields of crested wheatgrass were nearly double those in 1948, when spring precipitation was light. In 1949, acre-yields of crested wheatgrass on pastures used for light, moderate, and heavy grazing, respectively, were 861, 931, and 830 pounds as compared with 440, 494, and 476 pounds in 1948.

Intense grazing is already reducing the vigor of the grasses. This is shown by the relative number of days of grazing obtained from the average 100-acre pasture in 1949 as compared with 1948. In 1949, a definitely more favorable year, the number of cow days available under light, moderate, and heavy use were greater by 123, 94, and 36 percent on the 12 pastures in block I and by 148, 94, and 43 percent on the 12 pastures in block II.

Movement of soil, both during heavy rain and by heavy winds when the soil was dry, was noticeable on the heavily grazed pastures and on spots of the lightly grazed ones. No such movement was observed on the moderately grazed pastures. Heavy grazing removed too much of the grass over most of the pasture. Under light grazing some areas were little used and the plants produced numerous seed stalks. Later the cattle avoided these spots and concentrated on the previously grazed areas, overgrazing some of them. Under moderate use the pastures were more uniformly grazed.

Increased yields in the lightly and moderately grazed pastures are accounted for in part by the rapid filling in of spots where no crested wheatgrass stand had been previously obtained. These spots were at first occupied by cheatgrass, which is now being crowded out by crested wheatgrass.

Cattle gains in spring also reflected the damaging effects of heavy grazing (table 6). Gains under light and moderate grazing were practically the same. Only the last method of grazing, with the season shortened by 10 days at the end, gave a material difference from the other methods. This difference reflects the tendency for daily gains to be greatest early in the season.

Table 6. Average daily gains by cattle at three different intensities and under four methods of grazing, Benmore, 1949

Intensity	Pounds per day	Method	Pounds per day
Light	3.05	Rotation	2.66
Moderate	3.06	All spring (continuous)	2.88
Heavy grazing	2.49	10 days deferred	2.73
		10 days short at end	3.19

Sheep grazing - Ephraim

A study at Sorenson field near Ephraim, in which ewes and lambs are grazed on rye and crested wheatgrass pastures, showed good gains from both. A 7-year average was 0.52 pound per day for lambs and 0.31 pound per day for ewes from crested wheatgrass in comparison with 0.54 pound for lambs and 0.34 pound for ewes from rye pasture. The average grazing capacities were 6.1 sheep months per acre for crested wheatgrass and 5.7 for rye. Rye yields declined during the last half of the period. Rye also cost about twice as much per sheep month of forage, as it had to be disked in five of the seven years to maintain the stand.

The crested wheatgrass was in six 1½-acre pastures, two grazed lightly, two moderately, and two heavily, one set of three intensities being deferred about two weeks after the other set. Deferment has as yet showed little effect. Both heavily grazed pastures are being noticeably invaded by Russianthistle whereas in the lightly and moderately grazed ones, the vigor of crested wheatgrass has prevented weed invasion.

Seasonal trend in protein and phosphoric acid content of plants

Four species commonly used in reseeding (smooth brome, crested and slender wheatgrasses, and American vetch) were found to decrease in percentage of protein and phosphorus at biweekly intervals as the season advanced. The curve of decrease was similar for all species whether samples were taken in the high mountains (8,000 to 10,000 feet), in foothills (7,500 feet), or in the valley (5,500 feet). The periods of growth were longer at the higher elevations where it was cooler and more precipitation was received. These data are summarized in table 7 in which smooth brome and American vetch are used to illustrate trends.

Table 7. Content of protein and phosphoric acid (P_2O_5) in smooth brome and vetch at biweekly intervals at three elevations

Bi-weekly period	Smooth brome						American vetch		Date of sample
	High mountains		Foothills		Valley		High mountains		
	Percent		Percent		Percent		Percent		
	Protein	P_2O_5	Protein	P_2O_5	Protein	P_2O_5	Protein	P_2O_5	
1	23.7	1.18	12.4	0.89	13.7	0.86	35.2	1.54	June 3
2	20.6	0.76	10.1	0.63	11.5	0.37	25.2	0.93	June 17
3	15.9	0.64	9.3	0.48	9.8	0.35	22.5	0.83	July 1
4	10.4	0.53	6.8	0.40	8.1	0.24	20.6	0.63	July 17
5	12.5	0.45	5.4	0.39			18.1	0.57	July 30
6	9.0	0.48	4.7	0.50			12.2	0.47	Aug. 13
7	5.3	0.23	4.3	0.31			13.5	0.40	Aug. 27
8	7.9	0.31					10.6	0.37	Sept. 10
9	3.7	0.23					7.8	0.28	Oct. 10

The fact that plants at the three elevations were in different stages of development at given dates accounts for differences in stage of decline. The seasonal trend in composition of each species is clear, however, and this constitutes the principal point to be derived from the study. By the end of the growing season, both protein and phosphoric acid contents were low from the standpoint of animal nutrition.

Plans for 1950

The Benmore grazing experiments as a long-time study will be continued and also the smaller study comparing rye and crested wheatgrass on Sorenson field near Ephraim. Information on the results of grazing will be gathered as opportunity affords from areas managed by public agencies or private owners.

ACTION SEEDING BY REGION 4

The action program of range reseeding by Administration has been based on recommendations made from research of the Intermountain Station. Areas administratively seeded are: Nevada - 7,494 acres in 1949, total 27,952 acres; Idaho - 8,159 acres in 1949, total 78,541 acres; Utah - 27,421 acres in 1949, total 134,185 acres; Wyoming - 1,550 acres in 1949, total 8,015 acres. This makes a total of 44,624 acres seeded in 1949, and a grand total of 248,693 acres in the Intermountain region. All of the seedings were made by proved ground methods except in 1948 when 6,386 acres were sown experimentally with pelleted seed broadcast from an airplace. With this acreage deducted, as pellet seeding did not produce successful stands of grass, the total area for Utah is 127,799 acres and for the region 242,307 acres.

Other Federal agencies have seeded considerable areas, but their extent is not known. Large acreages have been seeded on private lands, most of them under PMA benefit payments. The best estimate that can be made without adequate figures places the total properly seeded by all public agencies and private land holders at not far from a million acres in the region.

On most large-scale seedings figures showing herbage production are not available. Records made by Station personnel on 6 areas in Idaho, 7 in Nevada, and 7 in Utah show a considerable series of actual yields. The growing season early in 1949 was very dry in central Idaho, about normal in Nevada, but rather moist in Utah and immediately adjacent parts of Idaho and Nevada. The yield data are given in table 8. Newer plantings show production for 1949 only, whereas on several of the older plantings production is shown for 1948 and 1949.

Table 8. Acreage and air-dry yields of some crested wheatgrass plantings in Idaho, Nevada, and Utah. Precipitation data are approximate averages

Location	Elevation	Precipitation	Acres	Pounds per acre	
				1948	1949
IDAHO					
Boise N.F. - Willow Creek	4,000	16	800	459	454
Boise N.F. - Cottonwood*	3,800	19	50	450	828
Private - Orchard	3,500	12	1,200	655	339
BLM - Raft River (N. of road)	5,000	10	8	430	765
BLM - Raft River (S. of road)	5,000	10	20	555	929
BLM - Sublette	5,000	10	20	-	582
NEVADA					
Humboldt N.F.) Stockmen & BLM) - Ruby Valley	6,200	15	815	-	1,403
Humboldt N.F. - Martin Creek	6,700	16	28	-	1,692
Humboldt N.F.) Stockmen & BLM) - Dinner Station	5,500	11	327	-	392
Humboldt N.F. - Goosey Flat	6,500	11	958	-	607
Humboldt N.F. - Buttermilk	5,000	9	600	-	406
Private - Wells	5,800	11	400	-	830
BLM - Goats's Corral	4,800	10	280	-	304
UTAH					
Manti N.F. - Dusterbery Ridge	8,500	26	45	1,650	1,700
Manti N.F. - Willow Creek	8,300	26	70	1,550	1,925
Private - Ephraim	5,500	11	40	650	820
Private - Ephraim	6,000	12	80	750	940
LaSal N.F. - Dry Mesa	8,100	20	1,000	750	1,000
LaSal N.F. - Nielson Pasture	8,500	23	400	800	1,050
LaSal N.F. - Joshua Flat	8,400	23	80	800	1,050

* Seeded in fall of 1947.

FOREST MANAGEMENT RESEARCH

If total cubic foot volumes of timber by regions is considered, the Intermountain region ranks third in the country in per capita inventory. In the reaches of the higher country are some 13 billion feet of sawtimber south of the Salmon River in Idaho, in western Wyoming, in Utah, and in Nevada. Within the region, southern Idaho has by the far the greatest volume of timber, followed by Utah, Wyoming, and Nevada. Ponderosa pine leads all other species in point of volume with a total of 4.5 billion feet on the national forests alone. There are 3.7 billion feet of Douglas-fir, 2.3 billion feet of lodgepole pine, 2.3 billion feet of Engelmann spruce, 700 million feet of true fir, and some 20 million cords of aspen. Idaho supports the greatest volume of ponderosa pine, Douglas-fir and true fir; Utah has a preponderance of Engelmann spruce, and Wyoming more lodgepole pine than any other species. The operable aspen is confined to Utah.

OBSTACLES TO SUCCESSFUL FOREST MANAGEMENT

While nature has provided forests in the Intermountain region, it appears she did so grudgingly. Her disinclination to nurture them is no less pronounced; harsh indeed are the conditions under which forest trees must grow. Commercial species are few in number and, with the exception of aspen confined to conifers. The altitudes at which forests are found restrict the growing season to less than 90 days free of killing frosts. The climate is arid with annual rainfall varying from some 20 to 30 inches where commercial forests are found. Unfortunately this precipitation is least in the growing season when it is most needed and when sustained high temperatures occur. Protracted summer drought causes discouragingly high mortality of seedlings and planted stock.

The unstable coarse granitic soil of southern Idaho, having a field capacity of some 12 percent and becoming quickly desiccated during the late spring and summer months, is a challenging medium for physiological response of vegetation.

Unlike the plateau country of Arizona and the more gentle slopes of other ponderosa pine territory, the topography of southern Idaho and Utah is rough, requiring many roads and careful handling of logging and hauling machines. This logging results in substantial soil displacement and every precaution of reseeding and slash disposal must be employed to decrease further erosion. With the exception of restricted areas of lodgepole pine in eastern Idaho, the forests of lodgepole and Engelmann spruce in the Intermountain region bear little resemblance to the same types in the Rocky Mountains insofar as topography and continuity of type are concerned. This fact complicates the already difficult problems in silvicultural management and timber extraction.

Under conditions of low summer rainfall, (1 inch, more or less), protracted hot weather, and low humidity as in southern Idaho, forest fires start easily and burn fiercely. They not only destroy forest vegetation which has taken years to become established and which is costly in time or money to replace, but highly undesirable vegetation follows in their wake creating more competition for forest reproduction and increasing the fire hazard simultaneously. This vicious cycle is constantly at work.

Disease and insects are annually making inroads into the growing stock of the forests in a way and to a degree which is becoming better understood--or at least appreciated--than heretofore. This whittling down of forest capital may be inconspicuous and difficult to detect and combat. In the future the close association between disease and insects may serve to explain phenomena which hitherto have been puzzling when interpreting mortality of both merchantable and unmerchantable trees.

PROBLEMS OF FOREST MANAGEMENT

There is less known about the silvics and silviculture of Intermountain forests, because there as been less research done on them, than of those in any other region in the United States. While a good start has been made towards the goal of good management there remains a tremendous task if optimum growth in all forest types and satisfactory utilization is to become a reality. What are some of these problems? Unquestionably the most important is management, not only of the virgin forests of which there still remain some 990,000 acres in southern Idaho, but also of the 303,000 acres of once-cut old growth stands. At present rates of cutting it is believed that putting these stands under management will require some 60 to 70 years to complete or at least two cutting cycles of 25 to 30 years each. How should these forests be cut? With what severity to reduce mortality the utmost? By what system of marking to secure the greatest growth per acre of saw timber? How should they be logged to keep soil loss at a minimum?

Mortality in sawtimber is the key to a reasonable growth per acre in southern Idaho and affects net growth more than any other single factor. But what are the exact causes of mortality, what specific insect, what specific disease? A marking system based on damage from a particular insect or a particular disease is a difficult and complex venture; there must be, perhaps, an intelligent and planned compromise.

The management of young second growth ponderosa pine stands presents another challenge. The utilization of young (90 years) second growth is a reality, not a conjecture. Available information on the management of these thrifty stands is meager. How soon should they be cut? How heavily should they be cut? How light a volume can be profitably logged? How many trees per acre should be pruned and how soon will these pruned trees be producing clear wood on the butt log?

There are about 209,000 acres in Region 4 on national forests in need of artificial regeneration. More is known about seeding and planting than other high priority problems, and yet results have been disappointing. Through annual fires this acreage increases annually as do the brush areas on the older burns, reducing the precarious amount of available soil moisture and producing excessive shade for seedlings. Why are burned areas promptly invaded by Ceanothus and to a lesser extent Prunus? One can only ruminate and reach a tentative decision. Facts would help answer this troublesome question.

About 25 percent of the seedlings that become established and survive are attacked by rabbits and porcupines resulting in disfigurement, weakening, or death. This depredation is repeated by porcupines when the trees are 10 to 30 feet high, causing crooked stems, often in the first log.

These are only certain phases of the more important problems confronting the forester who would undertake to manage the forest lands of southern Idaho. Additional important questions for other forest types of the region require answers so that efficient procedures may be followed by those charged with the management of this valuable resource.

PROGRAM FOR 1950

It is expected that a start can be made in 1950 to obtain some of the basic answers urgently needed for the ponderosa pine of southern Idaho. It is planned to start the installation of a methods-of-cutting study on a compartment basis which will evaluate two methods of marking (spacing and insect susceptibility), two severities of cut (light and medium), and three methods of logging (large tractor, jammer, and small tractor and horses).

From this layout, in due time, facts on soil loss, skidding costs by method and severity of cut, amount and periodicity of reproduction establishment, reduction in stocking from different skidding-severity of cut combinations, the nature, frequency, and periodicity of mortality, and a means of predicting growth, will be made available. All these data will serve a great and urgent need in the management of the cutover virgin ponderosa pine type and establish a starting point from which further research can be planned and carried forward.

FLOOD CONTROL SURVEYS

Flood control surveys of authorized watersheds are an important activity of the Station. There is an ever increasing public interest in insuring a continuing usable supply of water as well as a growing recognition of the relation of floods, erosion, and sedimentation to watershed use and condition. Flood survey reports provide a summary of watershed conditions, flood and sediment damages, economy, and a proposed program to alleviate the flood and sediment damages.

PROGRESS ON CURRENT SURVEYS

While work was completed on one report and initiated on several others, a large portion of the Division's effort during 1949 was spent in revising reports. These revisions included additional evaluations using cost indices to reflect future average prices, and adjustments of conservation benefits. Late in the year new instructions required the inclusion of the going programs of other agencies and evaluation of the proposed program by certain groups of measures.

Missouri River Basin. The flood control remedial program tabulations by groups of measures and by subbasins or areas of national forests for which this Station has responsibility were completed and forwarded for use in preparation of the forestry phases of the Comprehensive Agricultural Plan for the Missouri Basin.

Upper South Platte River Watershed. An interim report covering the flood control survey phases was prepared, reviewed, and distributed in-Service. A special report was prepared covering a study of engineering measures and hydrologic analyses of the proposed program for Bear Creek, a tributary of the South Platte. A preliminary report on infiltration investigations in the South Platte was also completed.

Sevier Lake Watershed. The 1948 draft of the Sevier Report was revised in light of staff review and an additional economic analysis in conformance with suggested price indices by the Bureau of Agricultural Economics. In March, Lobenstein was detailed to Washington to assist in the revision of this and other reports. The report was submitted to the Secretary's office and at the end of the year reviews were received from the Bureau of Agricultural Economics, Rural Electrification Administration, Extension Service, and Production and Marketing Administration.

Boise River Watershed. The 1948 draft of this report was being reviewed in Washington. By late spring comments were received from the Bureau of Reclamation, Corps of Engineers, and the Fish and Wildlife Service. Upon receipt of the Washington review the report was revised to reflect increased conservation benefits and later changes were made to reflect going programs and evaluation of groups of measures. At the end of the year the report was being prepared for reproduction.

Wasatch Front Watershed. A review by the Flood Control Division in Washington of a 1948 draft was received in midsummer. In light of the review, revisions were made in damages and also to reflect the effect of the Weber Basin Project of the Bureau of Reclamation which was recently authorized. Further revisions to include going programs and evaluation of groups of measures are being made.

Fountain River Watershed. The preliminary draft of this report which had been reviewed by the Washington staff was revised early in the year and distributed to FIARBC agencies and the Washington office for review. In the fall additional revision was started to reflect comments received. Changes in policy during the period necessitated additional field work in the collection of data on going programs.

Virgin River Watershed. Preliminary work on the Virgin River watershed was completed during the fore part of the year and field work, started in April, was completed in September. The Soil Conservation Service furnished assistance for determination of flood problems and their solution on private lands, and made a sedimentation study of the entire watershed. During the remainder of the year compilation and assembly of field data were carried on as other work permitted. This sparsely populated watershed, predominantly Federally owned, presents many problems similar to those that will be encountered in much of the Colorado Basin. Arid conditions, resulting in difficulty in establishment or slow recovery of vegetal cover, high sediment production, low damages, and the necessity for reliance on costly structural measures with high maintenance costs are some of the factors requiring consideration and solution.

Columbia River Survey. The first steps in planning the survey work for this important report were made. A detailed outline was prepared for the collection of data on watershed description, climate, stream flow, sedimentation, and species studies. A presentation of plans and proposed hydrology studies was given before the field committee in December.

A special field study of hydrologic conditions to determine the effect of snow storage and melting rates in forested areas adjacent to existing snow courses was begun late in 1949.

Infiltration runs with a type FA infiltrometer were made inside and outside big-game exclosures established in 1938. Three exclosures are located on the Gros Ventre and Hoback Rivers in Wyoming. Eleven years of protection appear to have allowed considerable improvement in infiltration rates and corresponding reduction in sediment production.

COOPERATION WITH OTHER AGENCIES

As in the past, effective liaison and cooperation with the Soil Conservation Service in the pursuance of flood survey work during the year was continued. A special report on recommendations for the forest lands was prepared for the Middle Rio Grande Report. Assistance was also provided the Soil Conservation Service on revision of the Gila River report. In the fall a preliminary field investigation of land cover, use and conditions of the forest and woodland portion of the Arkansas River below Pueblo, Colorado, in the states of Colorado and New Mexico was made.

The Soil Conservation Service has provided substantial assistance on agricultural lands on the Virgin River watershed survey as well as assistance in revision of the agricultural phases of the Wasatch Front and Fountain River surveys.

Mutual assistance between technical divisions of Regions 2, 3, and 4 and the Flood Control Division in the revision of flood survey reports and furnishing of watershed data occurred during 1949. This Division cooperated with Region 4 in a special erosion study of Dog Valley, California (Toiyabe National Forest), and on a watershed soil conference and field trip of the Regional office.

ADVANCE STUDIES AND OTHER INVESTIGATIONS

Upper Rio Grande River Watershed. A preliminary work outline and a field reconnaissance lasting several months, of cover, land use, condition and applicable remedial measures, were made on the forest and range portion of this watershed in Colorado.

Colorado River Watershed. Advance studies were initiated for this watershed. These investigations included preparation of base maps for subwatershed units, preparation of a preliminary vegetal cover map, and inventory of land condition, use, and ownership data from secondary source material. A start was also made on an analysis of sediment sources as well as on collection of hydrologic data. The Division conferred with Bureau of Reclamation personnel relative to a proposed infiltration investigation by the Bureau in the San Juan Basin.

Special investigations. A field examination and memorandum report of the floods of May 17-19 in Weber and Box Elder Counties, Utah, which caused flood and sediment damages of about $60,000 were made.

A memorandum report was also made (with field assistance by the Soil Conservation Service) of the flood of June 5 in the Florence-Portland area of Colorado which resulted in damages of about $500,000.

As a result of the August fires in the Payette National Forest this Division cooperated with the Influences Division in a field survey to observe the effects of the fire in Huntz Gulch and the Circle End area.

A memorandum report covering a reconnaissance sedimentation survey of the Tarryall Reservoir, Tarryall Creek (a tributary of the South Platte) in Colorado was completed and distributed in-Service.

PROGRAM FOR 1950

Flood control survey plans for 1950 are: (1) complete revisions on the Sevier Lake Watershed and reproduce final report; (2) complete revisions on the Boise Report and reproduce; (3) complete revision on the Fountain Report and reproduce; (4) complete revisions on the Wasatch Front report and resubmit; and (5) complete field work on the Virgin River survey and prepare preliminary draft of report and appendix.

In addition to survey report revisions, a problem analysis of the Colorado River watershed will be prepared.

Our major effort in 1950 will be concerned with the Columbia River survey and it is anticipated that most of the Division's time from late spring on will be spent on field work on this survey. Snow studies will be continued in the spring of 1950. These studies have been planned to continue through 1953 if possible.

As a result of conferences in Region 4 on the Comprehensive Agricultural Plan in the Columbia Basin, a preliminary note on soil relationship to land use and treatment as influenced by certain soil characteristics is being prepared by this section as an aid in coordinated program planning.

Assistance to the Soil Conservation Service will be given for further revisions of the Queen Creek, Gila River, Pecos, and Rio Grande surveys as well as survey work on the Arkansas River.

WATERSHED MANAGEMENT AND PROTECTION

This Division is responsible for the solution of watershed problems that affect the usefulness of runoff from the forest and range lands of the Intermountain region. There are about 190 million acres of these wildlands, or about 97 percent of the total regional area. One-half of the lands drain into the Great Basin of western Utah and northern Nevada, one-fourth drain into the Snake River in Idaho, a majority tributary of the Columbia, and the rest in southwestern Wyoming, eastern and southern Utah, and southern Nevada, drains into the Colorado.

Usable water in all three of these drainage basins is limited. Only one-fifth of the lands receives enough precipitation to yield runoff and two-thirds of this occurs in the spring and early summer during snowmelt, when water is not in great demand. These water-yielding lands are the steep, high altitude mountains and plateaus which rim the three drainage basins. Below these uplands are extensive foothills, benches, and valleys which receive too little precipitation to produce perennial streams. The humid, forested uplands are then the sole source of dependable water in the region.

The lowlands as well as the uplands, however, are subject to localized torrential summer rains. These storms rarely produce more than 1.50 inches of rain at a time, but rainfall frequently attains rates of 4 to 6 inches per hour for brief periods. These rains generally are of insufficient volume to exceed the water storage capacity of the soil mantle. They, therefore, produce virtually no seepage runoff. They are capable of producing much overland flow, however, especially on sparsely covered slopes.

Overland flow runoff, once set in motion by summer rains, is capable of generating violent discharges of water, mud, and rock. These floods are tremendously destructive where they debouch from canyons directly into communities or other developed property. Even those which occur in more remote canyons are also of great concern, for they pour large quantities of rock, sand, silt, and debris into larger streams which in turn carry these sediments farther downstream into reservoirs and out into irrigating canal systems. Summer floods are thus a dual menace: they cause direct destruction and also shrink an already limited water supply by displacing storage space in reservoirs. Without reservoirs to store surplus spring runoff, the economy of the entire region would collapse. So, also threatened by sedimentation is the expanding economy of the Pacific Northwest and the Pacific Southwest where people are becoming more and more dependent upon usable water from the headwaters of the Snake and the Colorado Rivers.

The delivery of useful water from the wildlands of this region presents three groups of watershed management problems. One involves the determination of where, how, and to what extent forage can be grazed and timber can be harvested without increasing destructive floods and damaging sedimentation. A second group involves the development of measures for achieving better control of runoff and greater stability of soil and other mantle materials on lands that have been damaged by overgrazing, fire, destructive logging, and other disturbances. A third group centers on the question of whether the amount and timeliness of useful water yields can be improved through manipulation of the forest and range cover.

Continued research during the past year has shed further light on several phases of these watershed management problems.

SAFE WATERSHED GRAZING USE

Two approaches have been used to determine the amount of grazing use that is compatible with watershed protection requirements. One has involved the measurement of runoff and eroded soil from paired 10-acre watersheds over a long period of years during which plant cover conditions have been changed by grazing. The other has involved the application of artificial rainfall to plots having different plant cover and soil characteristics to determine under which conditions there is a minimum of overland flow and soil loss. From these studies it appears that essentially similar plant cover and soil conditions are necessary for satisfactory control of summer storm runoff and soil stability on both the heavy clay soils of the subalpine herbaceous range in central Utah, and the very sandy, noncohesive granitic soils of southwestern Idaho.

Area A and B watershed behavior

In 1915 two 10-acre watersheds near the crest of the Wasatch Plateau in central Utah were equipped with runoff weirs and sediment traps to measure the effects of herbaceous plant cover and its use by grazing on storm runoff and erosion. During the past 35 years, plant cover conditions have been altered on the two areas by different intensities of grazing ranging from no use to overuse.

During the first 10-year period of this study Area A was in seriously depleted condition due to previous overgrazing. Plant cover density averaged only 16 percent on this area as compared to 40 percent on Area B. The latter area was grazed to maintain the same plant cover during this period. Area A was grazed lightly for the first few years and then was protected from grazing. During this period, Area A produced about 5 times more runoff and eroded soil per year than Area B.

In the second 10-year period of the study a 40 percent plant cover was maintained on both areas. The change in plant cover from 16 to 40 percent on Area A was accomplished by some reseeding and continued protection from grazing. The 40 percent plant cover on

Area B was maintained under what was judged to be conservative grazing use. During this second period Area A produced about 2.5 times more runoff and eroded material than Area B. Increasing the plant cover from 16 to 40 percent on Area A thus resulted in a substantial reduction of runoff and erosion relative to Area B. Area A continued to produce more runoff and sediment than Area B, however, due to topographic differences.

During the past 15 years, plant cover on Area A has been allowed to increase through continued protection from grazing and now averages about 50 percent. Area B has been deliberately overgrazed and now has an average plant cover of about 20 percent. Area B was first overgrazed during the period 1936 to 1940. During the war, it was not grazed. Beginning in 1945 it has since been overgrazed each year. During this third period of 15 years, Area B has produced from 2.5 to 3.0 times more runoff and sediment than Area A. This complete reversal of behavior is attributed to the reversal in plant cover conditions.

During the 35-year period of this study there has been much variation in the number and magnitude of summer storms. In general, more and larger rains occurred during the earlier years of the study than in recent years. During the past 2 years the data have been subjected to further analysis to determine trends in runoff and erosion behavior of each watershed over and above those due to differences in precipitation. In this analysis, estimates were made of the amount of runoff to be expected from storm events having given amounts of rainfall, given rainfall rates, and given amounts of antecedent precipitation. Differences between actual and estimated amounts of runoff were plotted chronologically. This analysis is nearing completion and has brought out some interesting differences in the behavior of the two areas.

Runoff from Area A decreased from considerably more than regression estimates to considerably less than regression estimates during the period 1915 to 1924. This initial period trend no doubt reflects the rather rapid increase in plant cover (from 16 to 40 percent) that took place toward the end of this study period.

Since 1924, runoff has continued toward less than regression estimates, but the trend has been slight. This area continues to produce storm runoff and sediment even though the average plant cover has increased from 40 percent to 50 percent through continued protection from grazing. The reason for only slight improvement in runoff control during these recent years lies in the fact that densely covered portions of Area A are interspersed with virtually barren and eroding areas which have failed to heal. Many of these areas are less than 100 square feet in size but all are connected to the main drainage channel by minor gullies which permit rapid runoff. These local sources of runoff and sediment show no signs of healing in spite of the protection from grazing disturbance they have had for 35 years.

The runoff trend for Area B during the period 1915-1936 is marked by an increase from less than regression estimates to more than regression estimates. This trend clearly indicates Area B was deteriorating though grazing use was at a level which maintained an average plant cover of 40 percent. This trend toward more runoff than regression estimates was even more pronounced during the period 1936 to 1940 when the area was deliberately overgrazed. During the war years, when the area was not grazed, the runoff trend changed toward less than regression estimates. With resumption of overgrazing since 1946, the runoff trend has again changed toward increasingly greater than regression estimates.

Throughout the Area B record, runoff has been substantially greater during storms that occurred after the area was grazed than during comparable storms that occurred before grazing disturbance. Current grazing disturbance on this particular area appears to step up runoff by about 20 percent.

Data from infiltrometer tests have shed light on the reasons for the differences in the runoff behavior of Area A and B and also indicate the minimum amount of plant cover that is needed for control of summer storm runoff. For example, sites with less than 10 percent of the ground covered by plants or litter lose as much as 90 percent of each high intensity rain as overland flow and this runoff carries away soil to the extent of 10 tons per acre. Sites with as much as 50 percent ground cover also produce excessive quantities of runoff and eroded material per storm. The minimum requirement for controlling storm runoff and keeping soil stable on sites having a light, friable, and highly organic soil appears to be a plant and litter cover on at least two-thirds of the ground surface. Sites having a heavy, compact soil with but little organic material--such as commonly develops on overgrazed and eroded areas--require a ground cover of as much as 90 percent for comparable runoff control.

It is now apparent that a 40 percent ground cover was never adequate for maintaining Area B in good condition. Similarly, though there has been marked improvement in the runoff behavior of Area A, parts of it will continue to deteriorate until a ground cover density of at least 65 percent is achieved over this entire area.

Protection requirements on coarse granitic soils

Ungrazed wheatgrass and cheatgrass ranges having coarse granitic soil in southwestern Idaho appear to have similar protection requirements to the subalpine herbaceous type of range found on the A and B watersheds in central Utah. To determine the protection requirements for the granitic soil ranges in Idaho, plots were subjected to 1.80 inches of constant rate rainfall in 30 minutes and the resultant amounts of runoff and eroded soil were related to each of eight measurable site characteristics. The site characteristics tested included slope gradient, soil depth, ground cover density, plant cover density, amount of erosion pavement, soil pore space, root abundance, and the maximum size of bare soil openings between plants and litter.

Total ground cover and maximum size of bare soil openings were found to be the two characteristics most highly related to overland flow and erosion on both range types. Overland flow and erosion decreased with increase in ground cover density and with decrease in the size of bare soil openings.

Ground cover density was the most influential site characteristic affecting overland flow. The controlling influence of a given ground cover density, however, was substantially decreased when the size of maximum bare openings was large, and was increased when the bare openings were small.

The size of maximum bare openings was the most influential characteristic affecting soil erosion. The effectiveness of this characteristic was lessened under conditions of sparse ground cover, and was increased under conditions of dense ground cover.

The goal of management for the best sites on wheatgrass range should be ground cover densities of 70 to 100 percent in combination with maximum bare openings of 4 inches or less. On good cheatgrass range sites, the goal should be a ground cover density of at least 70 percent and bare soil openings no larger than 2 inches. Attainment of these site conditions should result in less than 5 percent runoff and less than 250 pounds of soil loss per acre during major storms.

It is doubtful if a ground cover density of 70 percent or more can ever be attained on all portions of the wheatgrass and cheatgrass range in Idaho, especially on some of the south aspects having very shallow soils. The goal of management on these poorer sites should be as much ground cover as possible and the most uniform possible dispersion of plant and litter cover.

There is need for further tests on the coarse granitic soils to determine to what extent these management criteria apply on grazed range. Similar criteria are needed for the sagebrush, pinyon-juniper, and saltbush range, especially on slopes draining into the Colorado River in southeastern Utah.

SAFE WATERSHED LOGGING PRACTICES

Serious concern has developed throughout the region over the extent to which logging disturbance accelerates sediment production. Few facts are as yet available, but these are alarming. It has long been recognized that logging operations bare or otherwise disturb the soil on as much as 20 percent of an operating area and that the deeper scars such as those made on logging skid ways and yarding areas persist for many years. Sediment production on one area that had been logged and burned some 25 years previously was found to be equivalent to 0.25 acre-foot per square mile of drainage area per year as compared to less than 0.02 a.f./sq. mi./yr. on a virgin forest area. Another area which had been logged but not burned some 10 years prior to the time the sediment measurements were made was also found to be producing some 10 times more sediment than comparable unlogged forest land. Sediment production during the first several years after logging or burning no doubt was considerably greater. The seriousness of this acceleration in sediment production rates can best be appreciated when it is considered that all of the remaining commercial forest timber in this region will probably be harvested in the next 20 to 30 years. Meanwhile, second cuttings have already commenced and with them the reopening of old logging scars.

Thus far there have been no intensive studies of logging methods or of soil stabilization measures on forest lands in this region. During the past year, however, preliminary consideration was given toward the initiation of a study of the effects of logging on sediment production in ponderosa pine in south-central Idaho. This study will be an adjunct to a long-range experiment now being planned by the Division of Forest Management to determine the effects of different systems of cutting and logging on the growth and yield of ponderosa pine. More detailed planning of the sediment phases are to be made concurrently with final planning of the timber cutting and logging practices.

INCREASING USABLE WATER YIELDS

The search for feasible means of increasing the useful yield of water from watershed lands by manipulation of the plant cover was continued last year through the analysis of data from three separate studies. Two of these studies yielded further information on the extent to which the water storage deficit of watershed mantles is affected by evapo-transpiration processes during the summer growing season. A third study revealed how snow accumulation is affected by the kind of forest cover.

Aspen, herbaceous, and bare soil effects

Soil moisture determinations to depths of 6 feet have been taken during the past 3 years on sites having a normal aspen and herbaceous plant cover, herbaceous cover only, and no plant cover.

The analyses of these data show that total evapo-transpiration during the June 1 - September 15 growing season averaged about 18, 15, and 11 inches of water for the aspen, herbaceous, and bare sites, respectively. These amounts represent the evapo-transpiration deficit in 6-foot deep soil mantles, (the difference between moisture content at field capacity and that at the end of the growing season) plus summer rainfall, minus interception losses and surface runoff. Aspen used an estimated additional 1 inch of water in flower and early leaf development during the spring snowmelt period prior to June 1.

Evapo-transpiration deficits averaged about 12, 8, and 4 inches of water for aspen, herbaceous, and bare sites, respectively. These deficit differences reflect penetration of roots and withdrawal of water throughout the 6-foot mantle under aspen, to a depth of only 4 feet under herbaceous cover, and the absence of roots in the bare type.

Evapo-transpiration deficit represents the amount of water that must be replaced before free water can pass through the soil to stream or ground water. Accordingly, from a normal spring snow pack containing 30 inches of water, and without correction for any evaporation losses from snow, there would be available for stream flow about 17, 22, and 26 inches of water from the aspen, herbaceous, and bare sites, respectively. In a year when water in the snow pack is only 50 percent normal, or about 15 inches, water available for stream flow would be only 12, 32, and 42 percent of normal from aspen, herbaceous, and bare types.

Summer rains, which averaged about 7.0 inches per season produced 0.01 and 0.02 inch of overland runoff from the aspen and herbaceous sites, respectively. No soil was eroded from these areas. On the bare areas, however, rainstorm runoff averaged 0.40 inch per season and this runoff carried away the equivalent of about 8 tons of soil per acre.

These results suggest that removal of aspen--and probably other deep-rooted species--may be a means of increasing water yield provided this can be accomplished without increasing rainstorm runoff and soil loss.

Bunchgrass and annual weed effects

Reanalysis of soil moisture data obtained over an 11-month's period on a portion of the foothill range near Boise, Idaho, indicated that depleted annual weed range may yield slightly more seepage runoff than when reseeded to perennial wheatgrass. Evapo-transpiration losses during the spring and summer storms were 19.32 inches on annual weed sites and 17.83 inches on the wheatgrass sites. This difference is attributable to a more complete extraction of soil moisture by the deep taproots of the annual weed plants. During the late fall and early winter when there was unusable regrowth of grass, the perennial wheatgrass sites lost 2.21 inches of water as compared to 0.69 inch on the annual weed site. With the approach of the next spring runoff season, there was an 0.88 inch greater evapo-transpiration storage deficit in the soil mantle under the perennial wheatgrass than on the annual weed site.

These data suggest that annual weed cover may be slightly better than a more dense cover of wheatgrass from the standpoint of seepage flow runoff. However, the annual weed type is worthless as forage. Moreover, it is exceptionally inferior for controlling summer storm runoff and for maintaining soil stability. Sediment production from annual weed ranges in the vicinity of Boise, Idaho, and the Arrowrock Reservoir is on the order of 1.60 acre feet of sediment per square mile of drainage area per year. This rate is twice that of the Colorado River above Hoover Dam and about 80 times greater than from virgin forest areas adjoining the spring-fall range in the Boise River watershed. The forage value and the soil stabilizing effects of perennial wheatgrass cover more than offsets its slight cost in water consumption.

Snow accumulation and melting

A start was made on the analysis of data from a prewar study of snow accumulation and melting on ponderosa pine lands in southern Idaho. This forest is characterized by uneven-aged groups of trees which tend to develop an irregular canopy with numerous openings, both small and extensive. Snow measurements were obtained at 258 sampling stations at 15-day intervals beginning on January 1 and continuing through the melting period. The water equivalent values were summed for each station for one year and defined as a "storage-duration index." In all 3 years of record, areas occupied by saplings and brush openings stored the most snow for the longest period of time, as shown by the following tabulation:

Cover type	Snow-water storage duration index (inches)			
	1935	1936	1937	3-yr. av.
Mature and overmature	31.2	59.7	31.3	40.7
Poles	33.6	65.3	32.5	43.8
Saplings	40.0	76.0	41.3	52.4
Local brush openings	40.0	76.6	41.8	52.9
Extensive brush areas	26.2	58.2	27.9	37.4

Further analyses are under way to determine the effect of aspect and of the influence of individual tree characteristics on snow accumulation and melting.

PROGRAM FOR 1950

Efforts of this Division will be divided about equally between preparation of reports on a variety of studies, continuation of incomplete studies at the Great Basin, Wasatch, and Boise centers, and initiation of new studies at the Great Basin and Boise centers and in the Green River-Escalante River portion of the Colorado River basin. The major jobs within the four problem areas are as follows:

Great Basin

1. Complete report on effects of aspen, herbaceous, and weed cover on summer storm runoff and soil loss.

2. Complete analysis of A-B watershed and infiltrometer data and develop outline for technical bulletin.

3. Develop plan and initiate study to determine effects of intensive watershed improvement measures on sediment production from deteriorated subalpine herbaceous range probably in the vicinity of Pleasant Creek watershed. This is to be a cooperative study with national forest administration providing for installation of improvement measures and sediment traps.

4. Continue A-B watershed experiment to determine long range effects of natural recovery of subalpine herbaceous range on storm runoff and erosion. Continue no grazing on Area A; may continue grazing on Area B.

5. Continue runoff calibration records at Lefthand Fork, Alpine Cattle Pasture, Bluebell, and power plant stream gaging station as basis for testing effects of intensive watershed improvement measures on stream flow.

6. Explore possibilities of initiating a study in cooperation with national forest administration on effects of reseeding on sediment production within the sagebrush type in southern Utah.

Wasatch

1. Complete report on evapo-transpiration losses and water available to stream flow from aspen, herbaceous, and bare sites.

2. Complete report on interception losses from herbaceous and aspen-herbaceous plant cover.

3. Continue studies of effect of natural revegetation, artificial revegetation, and contour trenching on control of summer storm floods. This will involve maintenance of records on experimental watersheds and Parrish plots.

4. Complete analysis of sedimentation data from steep watersheds in Davis County, Utah.

5. Explore possibilities of initiating a study to determine effects of reseeding and grazing on shallow-soiled sagebrush range in Weber River basin on runoff and sediment production.

Boise

1. Complete report on watershed protection criteria for wheatgrass and cheatgrass range having coarse granitic soil.

2. Complete report on snow accumulation in ponderosa pine.

3. Complete report on evapo-transpiration losses from reseeded and weedy range.

4. Initiate study to determine effects of cutting and logging ponderosa pine on sediment production. This is an adjunct to new forest management methods of cutting study in the Boise Basin experimental forest. Sediment production to be measured from a subbasin within each of twelve 100-acre treated compartments and from four untreated small basins. National forest administration to help install the debris basins.

5. Continue infiltrometer study of runoff and erosion from wheatgrass and cheatgrass range as affected by grazing disturbance.

6. Explore possibilities for initiating a watershed study of the effects of reseeding and grazing deteriorated spring-fall range on runoff and sediment production.

Colorado

1. Make reconnaissance of sediment production areas in Green to Virgin portion of Colorado River in cooperation with Station staff and representatives of the Department of the Interior to locate study areas.

2. Initiate study of slope and channel sources of sediment.

3. Initiate infiltrometer study on effects of watershed conditions including grazing disturbance on storm runoff and erosion within the sagebrush, pinyon-juniper, and saltbush range types on areas having residual soils derived from shale, sandstone, mixed sands and gravel, and on areas having alluvial soils.

4. Explore possibilities of initiating a multiple watershed study to determine the effects of slope and channel treatment on runoff and sediment production.

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STATION PERSONNEL - C. Y. 1949

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